Speech Motor Control in English-Mandarin Bilinguals who Stutter

A thesis

Submitted in partial fulfillment

of the requirements for the Degree

of

MSc in Speech and Language Sciences

in the

University of Canterbury

By

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2013

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Acknowledgements

I would like to express my sincere gratitude to my supervisor, Professor Michael Robb for his continuous support of my MSc study and research. His enthusiasm and encouragement was my inspiration and I could not have imagined having a better supervisor and mentor. Special thanks to Dr. Emily Lin for extending her expertise, time and patience, for her support and insightful feedback on the statistical analysis of my data. Further, I would like to thank Gina Tillard and Tika Ormond for their kind words of support throughout the year and the invaluable clinical experiences that they have shared. In addition, I would also like to thank all participants who took part in my study. Thanks to Amanda Lee not only for providing reliability of my study but more importantly for her listening and reassurance. Many thanks to my friends and family for their love, support and belief in me. I could not have done this work without them. Thank you.

Abstract

Research examining bilinguals who stutter (BWS) is limited; in particular there are few studies that have considered examining features of speech motor control in BWS. The present study was designed to examine features of speech motor control in bilingual speakers of Mandarin and English. Speech motor control was examined through the acoustic analysis of speaking rate, voice onset time (VOT) and stuttering adaptation. Participants ranged from age between 9 and 27 years. Upon completion of a language dominance questionnaire, two BWS participants were found to be English dominant and three were Mandarin dominant. Each BWS participant was matched to age/sex matched control participants (BWNS). Results for the BWS participants found more stuttering in the less dominant language based on a measure of percentage of syllables stuttered. All of the BWS participants demonstrated stuttering adaptation and there was no significant difference in the amount of adaptation for Mandarin and English. There was no difference found between BWS and BWNS for speaking rate and VOT. In spite of the similarity between BWS and BWNS, speaking rate in Mandarin appeared to be faster compared to English. These findings suggest that speech motor control in BWS and BWNS are similar and current application of these findings to the clinical setting is discussed.

Introduction

Bilingualism

The term bilingual means two languages and encompasses the way two languages are used by a single individual (Kohnert, 2007). Two general classification of bilingualism are (1) age of acquisition and (2) proficiency. In regard to age of acquisition, it was previously thought that puberty was the upper limit for “perfect” second language acquisition (McLaughin, 1985). Shenker (2004) and Meisel (2004) described that the ideal form of bilingualism occurs prior to the age of four years. The age of acquisition is also related to the concepts of “simultaneous” and “sequential” bilingualism (McLaughlin, 1984; Shenker, 2004; Meisel, 2004). Simultaneous bilingualism refers to children who speak or have been spoken to in two or more languages since birth (Robb, 2010; Shenker, 2004). A person acquiring the second language (L2) after learning the first language (L1) is termed a sequential bilingual (McLaughin, 1984). These terms describes those who become bilingual as adults, as well as for others who became bilingual earlier in life (Halsband, 2006). By far, most bilingual speakers are sequential language learners.

When classifying bilingualism according to proficiency or skill, there are four language modalities that contribute to language proficiency. These four modalities are (1) listening comprehension, (2) reading comprehension, (3) speaking and (4) writing. Commonly described as a continuum, proficiency ranges from one end of the scale termed “passive bilingual” where a person may be a native speaker in one and is capable of understanding but not speaking another language to the other end, a “balanced bilingual” where a person is equally proficient in four language modalities (Roberts & Shenker, 2007). Siguan and MacKay (1987) further described the bilingual continuum as a range from “some degree of knowledge of a second language in addition to spontaneous skills which any individual possesses in his (her) first languages” to “the total, simultaneous and alternating mastery of two languages”.

The four language modalities determining proficiency are not easily measured as each can be more or less developed with influence from age of acquisition, type of exposure (e.g., TV vs. books), frequency of exposure (e.g., daily vs. weekly), and the context of which the language is used (e.g., school vs. work) (Roberts & Shenker, 2007). The label of bilingualism is used somewhat liberally and is attached to anyone who possesses at least one of the four language skills listed and has the ability to produce complete and meaningful utterances in the other language (e.g., a person who speaks a second language but is unable to read or write the language, a person who understand a second language but does not speak that language) (Baker, 2001).

Another concept of language proficiency is dominance. Some researchers have suggested that proficiency in only one modality (e.g., listening comprehension), can serve as the best indicator of language dominance, while others have suggested measures such as mean length of utterance, reaction time, fluency and speed of performance are also important indicators of dominance (Yip & Matthews, 2006; Daller, Yildiz, Jong, Kan & Basbagi, 2011; Bahrick, Hall, Groggin, Bahrick & Berger, 1994). Children learning two languages from birth seldom learn both languages in a similar manner. Often the languages develop at a different pace and consequently show dominance over one another (Saunders, 1988). Most researchers agree that a balanced bilingual with equal proficiency in both languages is rare (Grosjean, 1982).

Language dominance can alternate depending on external factors such as communication needs and environment (Daller et al, 2011; Olsson & Sullivan, 2005). Bahrick et al. (1994) found in their study of 801 Spanish-English speakers that first-language dominance shift is associated with living in a bilingual environment over a prolonged period and is task specific; English was used more frequently than Spanish in reading, writing and listening except speaking. Olsson and Sullivan (2005) supported the findings that dominance of a language is related to environmental context and is susceptible to change. For example, a person may use one language at home and with friends while he/she uses the other language mainly for work. In the Olsson and Sullivan (2005) study of a four-year-old bilingual Swedish-English speaking boy, it was noted that a shift in language dominance was observed from Swedish to English when the linguistic environment became primarily English. Dodson (1985) stated that a bilingual's dominant language is his or her preferred language for a specific domain of the individual's experience. Furthermore, Caldas and Caron-Caldas (2000) claim that a bilingual individual can have more than one dominant language depending on the language environment further supporting the notion that dominance is context sensitive.

Bilingualism and Motor Control

Speech production is a complex motor act that involves rapid sequential motor movements of fixed (e.g. teeth, palate) and movable (e.g. tongue, lips) articulators (Raphael, Borden & Harris, 2007). Simmond, Wise and Leech (2011) noted that learning a second language involves "retuning the neural circuits involved in the motor control of articulation, to enable rapid unfamiliar sequences of movements to be performed with the goal of approximating, the speech of a native speaker". Few attempts have been made to consider the influence of bilingualism on speech motor control. Changes in movement parameters such as speech rate and voice onset time (VOT) have been used to evaluate the nature of speech production in bilinguals (Chakraborty, Goffman & Smith, 2008; Zsiga, 2003; Evans, 2002). A general hypothesis in regards to motor control and bilingual speakers is that features of speech duration and variability differ significantly in regard to language proficiency. In particular, the less proficient language is likely to show higher variability and longer speech duration compared to the more proficient language. This situation is analogous to the classic results found for monolingual children compared to monolingual adults. Adults show more proficiency of the language compared to children and are found to produce speech with less variability and shorter durations (Kent 1976).

Chakraborty et al, (2008) examined oral motor coordination and speech rate in 21 Bengali (L1) – English (L2) speakers. Participants were grouped into early/high proficiency L2 and late/low proficiency L2 speakers based on age of acquisition and scores on standardized language tests. Measurement of lip and jaw movements revealed more variability in L1 speech movement patterns than L2. These results suggested that in bilinguals, proficiency differences in language are not reflected in measures of speech variability. This was in contrast to an initial hypothesis that in L1, bilingual speakers would show more consistent coordination patterns as compared with L2. On the other hand, results related to speaking rate found that the early/high proficiency group produced significantly faster speech rates than the late/low proficiency group for L1. Likewise, when comparing between languages, speech rate for the more proficient language (L1) was faster than the less proficient language (L2). Consistent with previous research on English-Mandarin speakers, L2 acquired at an older age is associated with slower speaking rate (Munro & Derwing, 1995).

In a later study, Chakraborty (2011) examined 20 Bengali (L1) - English (L2) bilinguals and ten monolingual speakers of English. The researchers investigated the relationship between proficiency and speech movement variability based on production on the syllable stress of real and novel words. Participants were grouped into high proficiency L2 and low proficiency L2 speakers. It was hypothesized that movement variability would be similar in both L1 and L2 (including high and low proficiency) for words with trochaic stress (e.g., CONtract), which occur frequently in both languages. On the other hand, for words with iambic sress (e.g., conTRACT) more movement variability was expected in the low proficiency L2 group compared to the high proficiency L2 group because Bengali does not have iambic prosody. The results did not find evidence in support of the hypothesis. Bengali-English speakers were not more variable in their production of iambs than of trochees indicating that L2 proficiency did not influence movement variability.

For many bilinguals, slower speech rates have been link to increased processing load, which may be related to reduced language experience (Munro & Derwin, 1995). Furthermore, increased speech rate is linked to maturation in children (Walsh & Smith, 2002). Research that has examined speech rate in bilinguals reported difference in speech rate of advanced L2 learners and bilingual speakers (Munro & Derwing, 1995; Riggenbach, 1991). According to

Bullock, Toribio, González and Dalola (2006), bilinguals also tend to show differences in voiced onset time (VOT). The alteration may be either diminished or increased VOT values in one or both of their languages when compared to those of monolingual speakers. Other researchers contend that VOT values are not fixed but tend to change according to the speech environment. Sancier and Fowler (1997) explained referred to this as "gestural drift" where the acquisition of the accent of the language community occurred past the critical period for language acquisition. For example a native speaker of British English, who has been living in the United States for many years, reports that his relatives in England tell him that he speaks with an American accent. Such research implies that bilinguals' language use is malleable in that they may behave differently according to which language they are producing or perceiving at a given time.

Bilingualism and Communication Disorders

For bilinguals, determining the presence of a language disorder can be difficult. Robb (2010) highlighted the difference versus disorder paradox describing it as "the challenge of distinguishing between aspects of linguistic variation that represent regular patterns in the speaker's language or dialect from those that represent true disorders in a language". A language difference is a situation in which the features of a language community differ from the majority language as a result of differences in pronunciation, production, or construction of language. Winter (1999), in postulating the implications for service delivery, stated a child's language community could account for the over-representation of bilingual children in speech and language therapy in some areas and under-representation in other areas. Winter (1999) claimed that this might be due to non-referral from interpreting speech and language difficulties as problems in learning English rather than recognizing that there may indeed be a disorder that underlies both languages. On the other hand, there may be more bilingual children receiving speech language therapy than needed because of the inherent lack of information to assess a bilingual child or fear of missing out on necessary therapy.

Contrary to popular belief, bilingualism does not increase the incidence of speech and language disorders in children. Over half of the world's population is bilingual and most of these children will learn to speak two or more languages without any obvious difficulties (Howell & Van Borsel, 2011). The reasons for difficulties with speech and language development are varied and complex but bilingualism is not attributed as one of them. Kohnert (2007) reported that the prevalence of communication disorders is the same for monolingual and bilingual children. Studies completed on dual language learners suggest that a bilingual environment does not put bilingual children at a greater disadvantage than their monolingual peers in language development (Genesee, Paradis & Crago, 2004).

A review of studies on bilingual children and communication disorders by Kohnert and Medina (2009) found that developmental language impairment is the most represented disorder. The available evidence shows that developing bilinguals may present with a range of communication disorders, as is the case with single language learners (Pena, 2000; Orgassa & Weerman, 2008). Bird, Cleave,Trudeau and Thordardottir (2005) found that young bilingual children with Down syndrome were comparable to their monolingual speaking peers with Down syndrome on measures of vocabulary and utterance length, indicating no evidence of a detrimental effect of bilingualism.

Studies on bilingual adults with a communication disorder focus mainly on acquired language disorders. The type of language disorder is dependent on the etiology. Some of the various adult language disorders described in the literature for bilinguals are aphasia, traumatic brain injury, dementia and right hemisphere disorder (Kohnert, 2007). For bilinguals with dementia, this may include using the wrong language for the setting or produce what appears to be an inappropriate mixture of their two languages (Friedland & Miller, 1999). Whereas, for adults with traumatic brain injury, language disorder depending on severity, nature and location of the injury may include anomia, impaired comprehension or poor turn taking (Kohnert, 2007).

Bilingualism and Stuttering

The relationship between bilingualism and stuttering was first noted in the 19th century, however, there is surprisingly limited research in this area (Van Borsel, 2011). The prevalence of stuttering in bilinguals is not known. Few studies on bilinguals who stutter (BWS) have been reported and the major focus of these studies is to compare the amount of stuttering in bilinguals and in monolinguals rather than explicitly describing prevalence of bilinguals who stutter (Van Borsel, 2011).

A review of the literature shows approximately 12 published studies (see table 1). Stuttering research in bilingualism is making slow progress due to the diverse population of bilingual speakers. The studies not only differ in regard to language type/combination, but also differ for age of acquisition of the second language, proficiency of the language, methodology in assessing stuttering and methodology in assessing bilingualism.

One common topic among past studies is the assessment of stuttering amount and severity in BWS and in particular whether bilinguals stutter in one or both languages. Dale (1977) studied four Spanish-English speaking boys who lived in the USA since birth and spoke only Spanish at home. All participants were found to stutter only in one language (Spanish.) Nwokah (1988) studied 16 participants who were bilingual in Igbo and English and found that their participants stuttered in both languages with severity varying from one language to the other. Similarly, Jayaram (1983), Jankelowitz and Bortz (1996), Bernstein Ratner and Benitez (1985), Shenker, Conte, Gingras, Courcey and Polomeno (1998) and Howell, Ruffle, Fernandez-Zuniga, Gutierrez, Fernandez, O’Brien, Tarasco, Vallejo Gomez and Au-Yeung (2004) all described that their bilingual participants stuttered in both languages but more so in one language when compared to the other. More recently, Lim, Lincoln, Chan and Onslow (2008a) replicated findings of Roberts (2002) showing an equal amount of stutters in balanced (simultaneous) bilinguals.

Linguistic variables that are closely linked with moments of stuttering in BWS have also examined and include (1) word class (2) sentence position and (3) phonemic characteristics. Results in general showed that stuttering occurred more on function words than in content words in young children and more on content words than function words in adults (Cabrera & Bernstein Ratner, 2000, Howell et al 2004, Schäfer & Robb, 2012). With regards to sentence position, words occurring at the beginning of a sentence attracted more disfluencies than the same words placed at the end of the sentence (Bernstein Ratner & Benitez, 1985). In a study of 10 bilingual Kannada-English speakers, Jarayam (1983) discovered that for both languages, participants were most disfluent on voiceless fricatives and nasals.

Table 1. Summary of studies examining stuttering behavior in bilingual speakers. The table includes the number of participants in each study and languages spoken by participants.

Study	No of participants	Languages spoken
Dale (1977)	4	Spanish-English
Jayaram (1983, 1984)	10	Kannada-English
Bernstein Ratner & Benitez (1985)	1	Spanish-English
Nwokah (1988)	16	Igbo-English
Jankelowitz & Bortz (1996)	1	Afrikaans-English
Shenker et al. (1998)	1	English-French
Roberts (2002)	4	French-English
Howell et al. (2004)	1	Spanish-English
Lim et al. (2008a)	30	English-Mandarin
Schaefer & Robb (2012)	16	German-English
Ardila, Ramos & Barrocas (2011)	1	English-Spanish

Stuttering in English-Mandarin Bilingual Individuals

English and Mandarin are two of the most frequently spoken languages in the world yet little information is available about stuttering patterns in Mandarin and especially in bilinguals who speak both English and Mandarin. There are approximately 1 billion Mandarin speakers and 500 million English speakers worldwide (Grosjean 1982, Lewis, 2009). To date, the most comprehensive study of English-Mandarin speakers who stutter was by Lim et al. (2008a). Lim et al. investigated the manifestation of stuttering in both languages and whether bilinguals show differential stuttering in the two languages. The following four questions were raised (1) Do English-Mandarin bilinguals who stutter (BWS), stutter more frequently in one language compared to the other? (2) Do English-mandarin BWS stutter more severely in one language compared to the other? (3) Is the type of stuttering different across languages? (4) Is the severity and type of stuttering influenced by language dominance?

Thirty English-Mandarin bilingual participants who stutter were involved in the study. The criteria used to determine language dominance were based on the participants' self rating of language proficiency, frequency of language use and domains of language use across fours language modalities specifically: understanding, reading, writing and speaking. A total of 15 participants were grouped as English-dominant, four were grouped as Mandarin-dominant and 11 as balanced bilinguals. The percentage of syllables stuttered (%SS) and severity rating (SEV) were determined. Types of stutters exhibited in each language were also analyzed using the Lidcombe Behavioral Data Language (LBDL). Using these measures, the data collected from a 10-minute conversational sample in both English and Mandarin were examined for each participant.

Results indicated that all participants exhibited stuttering in both languages. These findings were consistent with other bilingual research findings. The researchers also found that the English and Mandarin dominant participants exhibited greater stuttering in their less dominant language. This finding supports Nwokah's (1988) "difference hypothesis" where bilinguals who stutter had disproportional levels of disfluencies. In addition, the balanced bilinguals were found to have the same level of stuttering in both languages.

Bilingualism, Motor control and Stuttering

Few studies have looked into the influence of motor control on BWS. Evans (2002) conducted a study on oral motor rehearsal theory by measuring the adaptation effect in two adult BWS. The adaptation effect was first identified by Johnson and Inness (1939). The effect represents a decrease in the amount of stuttering with repeated reading of the same passage. By changing the language of the passage read during the experiment, Evans found atypical adaptation over 10 readings characterized by a dramatic increase in stuttering following a change of language from L1-L2 and a decrease in stuttering following change in language from L2-L1 in participant 1. The results from participant 2 also showed the opposite pattern of an increase in stuttering following a change of language from L2-L1 but with non-significant changes when language changed from L1-L2. Evans (2002) explained these findings to be an interactive effect between language proficiency and a change in the oral-motor plan.

To date, no studies have looked at speech rate and VOT as measurements of motor control in bilinguals who stutter. Yet, these two features of speech motor control have been found to vary in bilingual speakers who do not stutter (BWNS) (Chakraborty et al., 2008 and Bullock et al., 2006). Stuttering is often reported as a form of motor speech disorder (Duffy, 2005). It is unclear as to the relationship between speech motor control found in BWNS and BWS.

Statement of the Problem

Bilingualism can be classified in a number of ways based on age of acquisition and/or proficiency. Chakaborty et al. (2008, 2011) suggest that the speech motor control found in bilingual speakers can be influenced by language proficiency. Bilingualism has been examined in various communication disorders particularly in regards to language development in children and acquired language disorders in adults. Information related to BWS is slowly accumulating; however past research has been limited to identification of stuttering frequency and severity. The sole study of English-Mandarin BWS was conducted by Lim et al. (2008a) and found more stuttering in the less dominant language and an equal rate of stuttering in balanced bilinguals. The only available study examining speech motor control in BWS suggested inconsistent adaptation patterns linked to language proficiency and oral motor interaction (Evans, 2002). The purpose of the present study was to further explore features of speech motor control in BWS, with a particular focus on bilingual speakers of English and Mandarin. The following questions were posed:

(1) Do bilinguals who stutter (BWS) show more stutter in one language compared to the other?

(2) Do BWS show the same speaking rate between the less dominant and more dominant language? Is this pattern the same compared to a control group of bilinguals who do not stutter (BWNS)?

(3) Do BWS show differences in VOT between the less dominant and more dominant language? Is this pattern the same compared to a control group of BWNS?

(4) Do BWS exhibit stuttering adaption in both languages? Is there a difference in the amount of adaptation between languages?

Method

Participants

Participants for this study included five male bilinguals who stutter (BWS) and a control group of 10 bilinguals who do not stutter (BWNS). All participants were bilingual speakers of Mandarin and English. A self report classification tool described by Lim et al. (2008b) was used to divide the BWS participants into two language dominance groups: English-dominant (two participants), and Mandarin-dominant (three participants). The BWNS group was matched for age (± three years), gender and language dominance to the BWS group at a ratio of 2:1. The use of twice as many control participants was undertaken to estimate a baseline of "normal" speech motor control for comparison to the BWS participants. The age of the participants ranged from 8 to 27 years-old with a mean of 21 years-old. In order to be eligible for participation in the study, each BWS participant had to meet the following criteria: (1) exhibit more than 2% syllables stuttered in a spontaneous speech sample of 300 words in the dominant language, and (2) no other self-reported communication disorders. The severity of each BWS participant was determined using the Stuttering Severity Instrument (SSI-3) (Riley, 1972). The results are shown in Table 2.

Table 2. General characteristics of bilinguals who stutter (BWS). The table shows the results from the Stuttering Severity Instrument (SSI-3), including the percentage of syllables stuttered (%SS).

BWS	Sex	Age	Dominant Language	SSI-3 Mandarin				SSI-3 English				Current Treatment
				Raw Score	Percentile	Severity	%SS	Raw Score	Percentile	Severity	%SS	
BWS 1	M	8; 8	English	17	24-40	Mild	9.0	15	12-23	Mild	6.3	Yes
BWS 2	M	25; 3	English	15	5-11	Very mild	11.7	11	1-4	Very mild	6.6	No
BWS 3	M	25; 1	Mandarin	32	78-88	Severe	24.7	32	78-88	Severe	20.5	Yes
BWS 4	M	23; 10	Mandarin	8	0	-	3.0	13	5-11	Very mild	6.1	No
BWS 5	M	26; 7	Mandarin	18	12-23	Mild	9.0	19	12-23	Mild	6.5	No

Table 3. General Characteristics of bilinguals who do not stutter (BWNS).

BWNS Control group 1	Sex	Age	Dominant Language	BWNS Control group 2	Sex	Age	Dominant Language
1a	M	10;10	English	1b	M	9; 9	English
2b	M	25; 7	English	2a	M	26; 3	English
3b	M	25; 7	Mandarin	3a	M	27	Mandarin
4a	M	20; 6	Mandarin	4b	M	22; 7	Mandarin
5a	M	24; 2	Mandarin	5b	M	25; 11	Mandarin

Speech Sampling

Three types of samples were collected. One sample involved collection of connected speech taken from a picture description task. Another sample involved collection of single word production of 30 words in Mandarin and 30 words in English. Each of these words contained stop consonants (i.e. /p/, /t/, /k/, /b/, /d/, /g/) in word-initial position. The third sample was oral reading of the Rainbow Passage (100-words) (see Appendix 5). The passage was read aloud 5 times in English and 5 times in Mandarin.

In the picture description task, two pictures were used (see Appendix 3). Each participant was shown one picture at a time and asked to describe one picture in English and one picture in Mandarin. In the single word production task, participants was asked to name one set of 30 written words in English (5 words per stop consonant) and one set of 30 grapheme words in Mandarin (see Appendix 4). The Mandarin word was presented with printed grapheme and orthography below the grapheme using Hanyu Pinyin. Words were presented in the form of a PowerPoint presentation on a computer monitor. The reading task involved each BWS participant reading aloud the Rainbow Passage in English and an identical version translated into Mandarin. Each passage is read five times with no rest periods given between successive readings. An audio-video recording was completed from a front-on head-shots recorded in a quiet, well-lit room, The recording was completed using a built-in camera and microphone on a MacBook computer. A mouth-microphone distance of approximately 15cm was maintained.

Procedure

Case history taking and the initial interviews were conducted in English by the researcher who is an English-Mandarin bilingual speech-language therapist (SLT). All BWS participants underwent a standardized initial assessment protocol involving case history collection, a diagnosis of stuttering using the SSI-3 and the completion of a self-report classification tool. The connected speech samples for each participant in English and Mandarin was used for determining the percentage of syllables stuttered (%SS) and speaking rate (spm). Each participant spoke for approximately 7-10 minutes. All participants were video and audio recorded once being engaged in a spontaneous conversation with the researcher about the picture being shown. The topic of conversation between participants was similar. The researcher used open-ended questions posed to each participant in a picture description context to elicit speech samples. The entire spontaneous speech sample for each participant was used to calculate %SS by using the number of stutter-like disfluencies determined based on orthographic transcription. Stutter-like disfluencies were defined as those containing part word repetitions, prolongations, blocks and/or single syllable word repetition (Ambrose, 2006). The utterances that were included into the database for speaking rate measurement were defined as a string of words (syllables) that communicated an idea, excluded non-speech sounds and did not contain a silent interval in excess of 250ms (Flipson, 2002; Hall, Amir & Yari, 1999). Single words productions containing phonemic stops were used to analyze voice onset time (VOT). Each word was embedded in the carrier phrase 'say ____ again' for the English set and 'shuō ____ yí cì' for the Mandarin set. The carrier phrase was used to encourage naturalistic productions and to minimize intrasubject variability in stress patterns and fundamental frequency contours (Sweeting & Baker, 1982). Productions with interference (e.g., background noise) were discarded. A version of the Rainbow Passage in English containing 100 words and a translated version in Mandarin was used to calculate stuttering adaptation as well as %SS. The order of presentation for the speech sample collection tasks, stimuli and languages were randomized.

Acoustic measures

Speaking Rate

Speaking rate was based on the connected speech sample and only utterances that were perceptually fluent were measured. Each participant's audio-recorded fluent utterances from the conversational sample were simultaneously displayed on a computer monitor as an amplitude-by-time waveform and as a wideband spectrogram using a speech analysis program (PRAAT). On the basis of this dual display, a vertical cursor was placed at the onset of the first syllable of the fluent sample and a second cursor was placed at the offset of the last syllable in the fluent conversational sample. Syllable onset was taken to be the point on the displays where acoustic energy could first be detected. Offset of the last syllable was the point at which acoustic energy could no longer be detected. The time interval between the two cursors was recorded as the total duration. The total number of syllables produced in the sample was divided by the total duration to derive speaking rate. The unit of measure for speaking rate was the number of syllables produced per minute (spm). Speaking rate was determined for each participant in the BWS group and BWNS group.

Voice Onset Time

Each audio-recorded word-initial CV was digitized at 10kHz using a speech analysis system (PRAAT) and simultaneously displayed on a computer monitor as an amplitude-by-frequency display wideband and as a sound spectrogram. A pair of vertical cursors was overlaid on the displays. The left cursor was positioned at the burst release and the right cursor was placed at the first instance of vocal fold vibration at the level of the second formant (Klatt, 1975). The VOT was measured for both the BWS and BWNS participants. The VOT was defined as the time interval between cursors and reported in milliseconds.

Adaptation Effect

The researcher used both the audio and videotaped recordings to perform frequency counts of stuttering from each of the five successive readings in English and Mandarin for the BWS participants. Stuttering frequency counts were performed on typed copies of passages by playing back the recorded samples as many times as necessary. The stuttering frequency counts were based on the occurrence of stutter-like disfluencies (Ambrose, 2006). To aid in the comparison of stuttering frequency counts between languages, all data were presented as a percentage of stuttered words as opposed to number of stuttered words. Calculation for percentages of adaptation and stuttering were determined for individual BWS participants. Percentage of adaptations was calculated using the following formula: 100(A-B) A, where A equals the numbers of stuttering occurrences in a prior reading and B equals the number of occurrences of stuttering in any subsequent reading. The process for determining the adaptation effect was similar to that used by Neelley and Timmons (1967) and Evans (2002).

Data Analysis

Individual values for each of the acoustic measures were determined. These measurement values were combined for each group (BWNS and BWS) and language variety (Mandarin and English). In addition, BWNS participants were randomly assigned to either Control group 1 or Control group 2 for analysis. Within the BWS group, a statistical comparison was made between English and Mandarin. Likewise, between each group, a comparison was made between English and Mandarin. Statistical tests were performed to determine whether there was a significant difference between groups and language variety.

Statistical Analysis

The SPSS software was used for statistical analysis. The statistical significance level was set at 0.05. The descriptive statistics of the measures of speaking rate and VOT were derived for each participant and for the BWNS and BWS groups across the two languages, Mandarin and English. To determine whether the speaking rate varied by language and stuttering status, a two-way (2 languages X 3 groups) Mixed model analysis of variance (ANOVA) was performed on the speaking rate measures, with language treated as a within-subject factor and group as a between-subject factor. To determine whether VOT varied significantly by language type (Mandarin & English), speaker group (BWS & BWNS), as well as the place of articulation (bilabial, alveolar, & velar) and voicing condition (voiced & voiceless) of the word-initial stops, a four-way Mixed Model ANOVA was performed on the VOT measures. Speaker group was treated as the between-groups factor and language type, place of articulation, and voicing condition treated as the within-groups factors.

Reliability Measures

Several types of measurement reliability were performed. The first measure was specific to the identification of stuttering severity based on the SSI-3. The second measure was specific to VOT duration of stop consonants. The third measure was specific to speaking rate in conversational context and the fourth measure was specific to stuttering adaptation. Both inter- and intra-judge forms of reliability were undertaken. Inter-judge reliability measures were completed with the assistance of another English-Mandarin bilingual speech-language therapist, currently undertaking her PhD. Participants were chosen randomly for the reliability measures. SSI-3 was recalculated for 1 BWS participant using the recording of the conversational speech sample, reading of the rainbow passage and observation of behaviours. Inter- and intra-judge measurements for English yielded the same severity rating of mild. The intra-judge measure for Mandarin has also the same severity rating of mild as the first measure, whereas the inter-judge measure showed a slightly lower severity rating of very mild compared to the first measurement. The VOT samples of two participants (1 BWS & 1 BWNS) consisted of 5 VOT productions randomly selected from each participant and each language. The intra-judge difference calculated for the VOT samples in English and Mandarin averaged to be 3.95

ms and 2.20 ms, respectively. The inter-judge difference calculated for the same VOT samples in English and Mandarin averaged to be 0.30 ms and 2.20 ms, respectively. The conversational sample of two participants (1 BWS & 1 BWNS) in English and Mandarin were analyzed and showed an average difference of 0.51 secs and 0.39 secs, respectively for inter-judge measurements and 0.45 secs and 0.37 secs, respectively for intra-judge measurements. Stuttering adaptation was reanalyzed by listening to the recording of one BWS participant reading a passage 5 times in English and 5 times in Mandarin. Inter- and intra-judge measurements showed 100% similarity for English. For stuttering adaptation in Mandarin, the intra-judge re-measurement was 100% and inter-judge re-measurement was 86%.

Results

Speaking Rate

The mean speaking rates for each of the five BWS and their two normal controls are displayed in Figure 1. A visual inspection of Figure 1a revealed, that BWS 1 who was English-dominant and showed mild stuttering in both languages (see Table 2), had a higher speaking rate in both languages compared to the control participants. When comparing Mandarin and English for BWS 1, BWS 1 showed a slightly faster speaking rate in English than in Mandarin (see Figure 1a). In both languages for BWS 2 who was also classified as an English-dominant bilingual but judged to have only a very mild degree of stuttering, a visual inspection of Figure 1b revealed that, for both languages, the speaking rate of BWS 2 was marginally slower compared to one control participant (2b) but faster than the other control (2a). Unlike BWS 1, BWS2 had a faster speaking rate for Mandarin than English (see Figure 1b). As for the three Mandarin-dominant bilinguals in the BWS group, both BWS 3, who showed severe stuttering, and BWS 5, who showed mild stuttering, had a slower speaking rate than both controls in both languages and a higher speaking rate for Mandarin than for English (see Figures 1c and 1e). For BWS 4, who was judged to have no stuttering in Mandarin but a very mild degree of stuttering in English, speaking rate in Mandarin was also faster compared to English. When compared to both BWNS controls, BWS 4 had a faster speaking rate than the controls for Mandarin but an English speaking rate similar to that of the controls (see Figure 1d).

Across the five BWS participants, the speaking rate ranged from 3.95 to 6.47 sps (M = 5.19) for Mandarin and from 3.3 to 5.26 sps (M = 4.45) for English. Across the five BWNS participants in control group 1, the speaking rate ranged from 3.68 to 6.5 sps (M = 5.06) for Mandarin and from 3.5 to 5.37 sps (M = 4.69) for English. Across the five BWNS participants in control group 2, the speaking rate ranged from 2.36 to 5.39 sps (M = 4.57) for Mandarin and from 2.2 to 5.28 sps (M = 4.44) for English. To determine whether the speaking rate varied by language and stuttering status, a two-way (2 languages X 3 groups) mixed model analysis of variance (ANOVA) was performed. Results of the two-way (2 languages X 3 groups) Mixed Model ANOVA conducted on the speaking rate measures revealed a significant language effect [$F(1, 12) = 4.879$, $p = 0.047$] but no significant group effect [$F(2, 12) = 0.2$, $p = 0.821$] or language-by-group interaction effect [$F(2, 12) = 0.906$, $p = 0.43$]. Overall, the mean speaking rate was found to be significantly higher for Mandarin ($M = 4.93$ sps) than for English ($M = 4.52$ sps), regardless of speaker group. The overall mean speaking rate for the BWS group and the two BWNS control groups for both languages is shown in Figure 2.

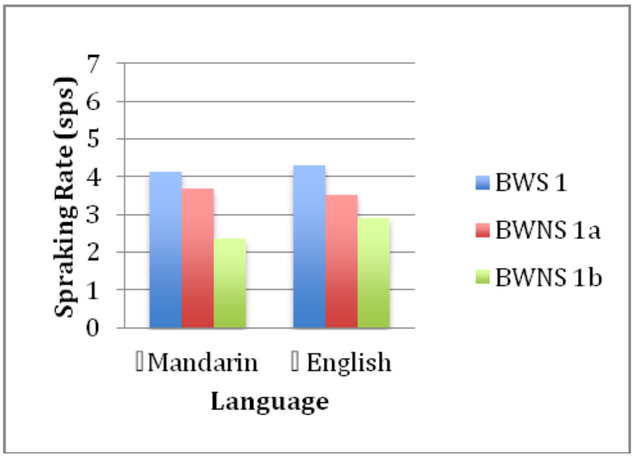

Figure 1a

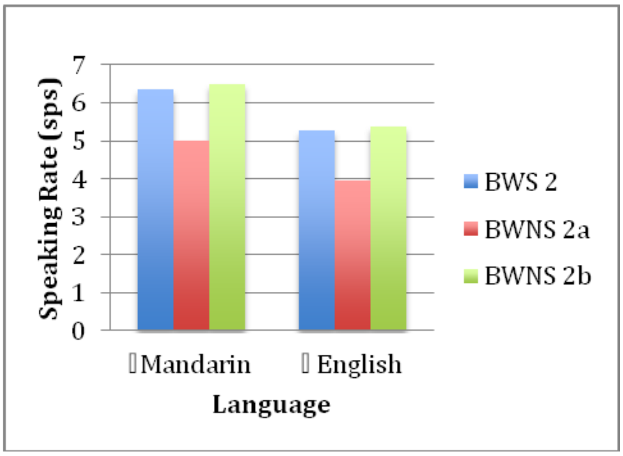

Figure 1b

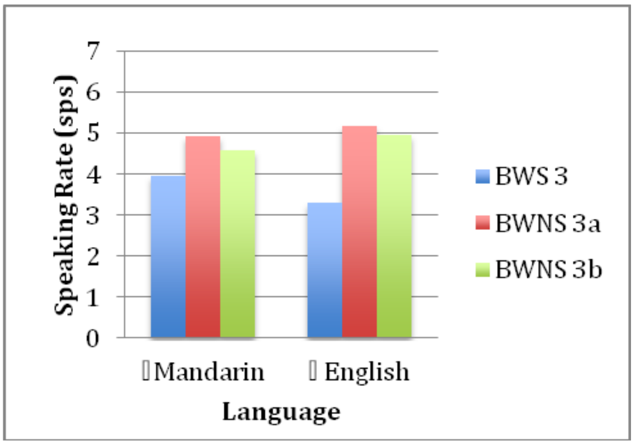

Figure 1c

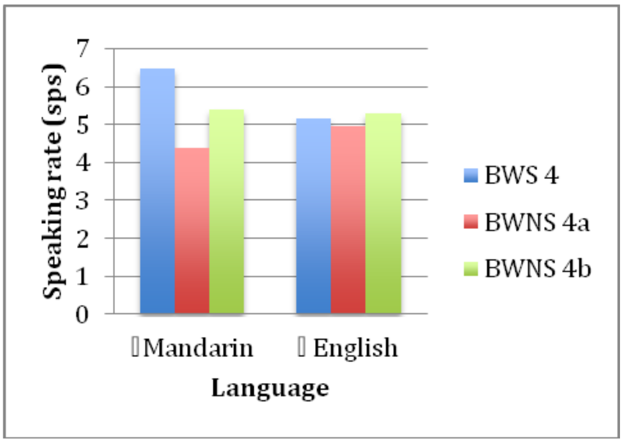

Figure 1d

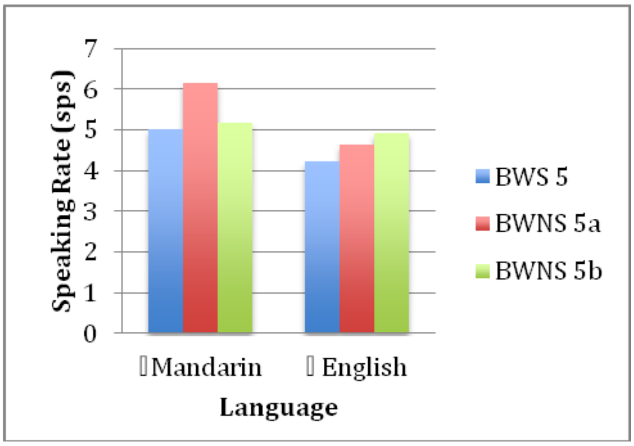

Figure 1e

Figure 1. Mandarin and English speaking rates (in syllables per second) for the bilinguals who stutter (BWS) and the bilinguals who do not stutter (BWNS). BWNS (a and b) participants matched to each BWS.

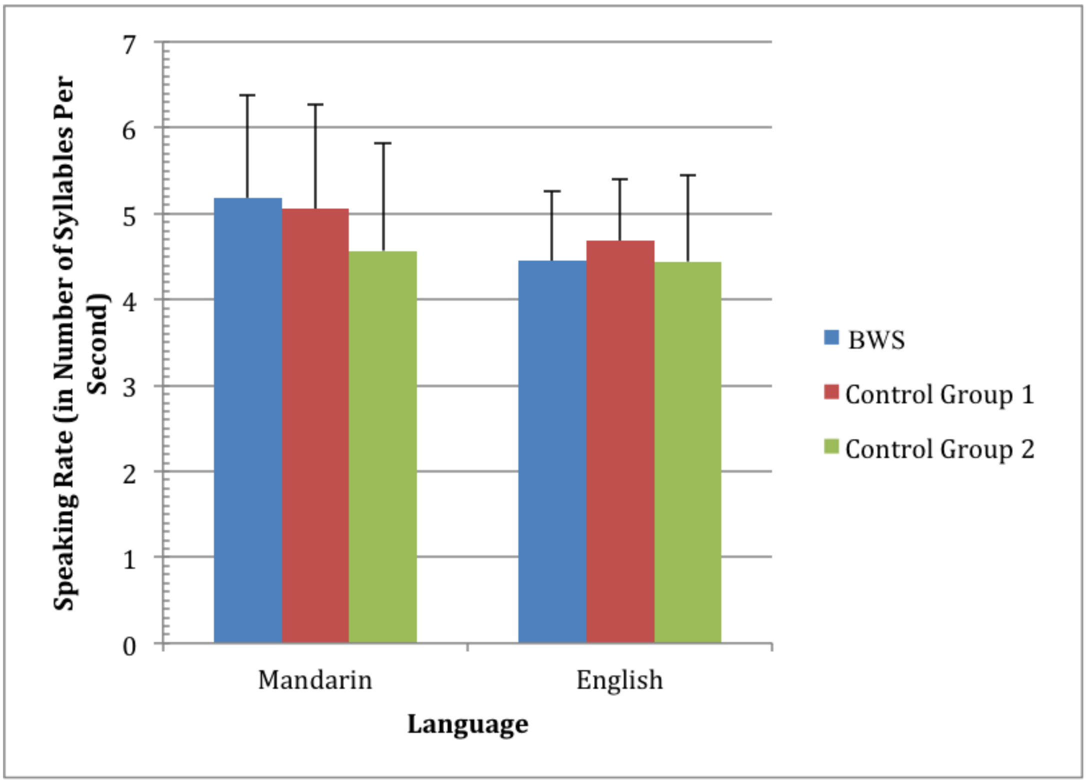

Figure 2. Mean speaking rate for the BWS group and the two BWNS control groups for Mandarin and English, respectively. The error bars show the standard deviations.

Voice Onset Time (VOT)

Mandarin

The results of the VOT analysis for each BWS participant and the BWNS controls are displayed in Figures 3a-3e. For all BWS participants there was a clear difference in the VOT for voiceless stops (/p/, /t/, /k/) compared to voiced stops (/b/, /d/, /g/). For BWS 1 (English-dominant), the majority of the voiceless stops VOT were shorter than both controls. The VOT for /b/ was slightly longer in BWS 1 compared to the controls but the other two voiced stops were marginally similar to both BWNS (see Figure 3a). Similarly for BWS 2 (English-dominant), the VOT measures for voiceless stops were shorter than both controls. The VOT of /b/ was similar to the controls but the VOT for /d/ was slightly longer compared to both BWNS controls (see Figure 3b). For BWS 3, the VOT for all voiceless stops was longer compared to the controls, and the VOT for two voiced stops (/b/ and /g/) were shorter compared to both BWNS (see Figure 3c). For voiced stop consonants, BWS 4 exhibited similar VOTs compared one control (BWNS 4b) but noticeably shorter VOTs compared to the other control (BWNS 4a). The VOTs for /b/ and /d/ produced by BWS 4 were shorter compared to one control BWNS but longer compared to the other control BWNS. Lastly, for BWS 5, the VOTs for /p, d, b, g/ were longer than both BWNS controls, whereas for /t/ and /k/, the VOTs for BWS 5 were slightly shorter compared to one BWNS but noticeable longer compared to the other BWNS.

Figure 4 shows the average VOT measures across different Mandarin stop consonants for each of the three participant groups (i.e., BWS group, BWNS control group 1, and BWNS control group 2). As shown in Figure 4, voiced stops were associated with a shorter VOT than voiceless stops in Mandarin. Specifically, the VOTs averaged for the BWS group for the Mandarin /b/, /d/ and /g/ were 12.40 ms, 16.52 ms, and 24.12 ms respectively while those for the Mandarin /p/, /t/, and /k/ were 101.16 ms, 103.48 ms and 117.6 ms respectively. For the BWNS control group 1, the average VOTs for the Mandarin /b/, /d/, and /g/ were 12.24 ms, 12.68ms, and 24.94ms respectively while those for the Mandarin /p/, /t/, and /k/ were 106.56 ms, 121.04 ms, and 125.16ms respectively. For the BWNS control group 2, the average VOTs for the Mandarin /b/, /d/, and /g/ were 10.92 ms, 12.72 ms and 22.12 ms respectively while those for the Mandarin /p/, /t/ and /k/ in the BWNS control group 2 were 94.84 ms, 106.08 ms, and 105.48 ms respectively.

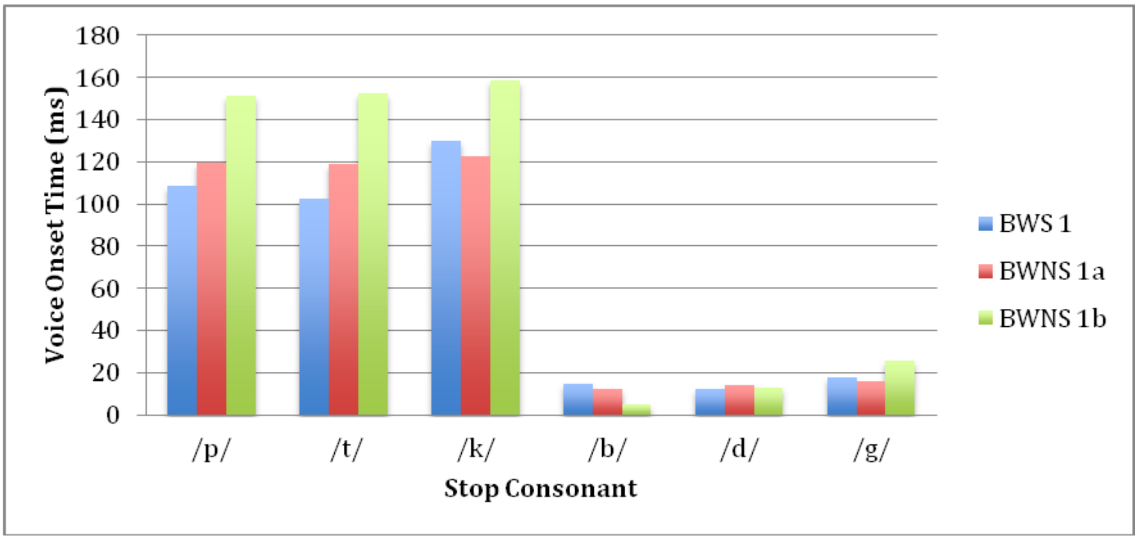

Figure 3a

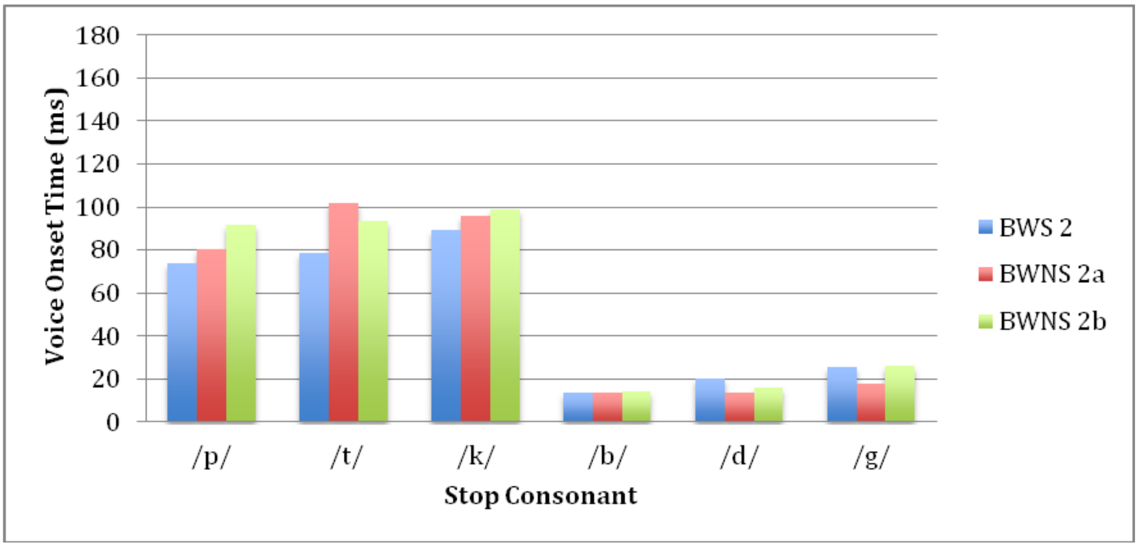

Figure 3b

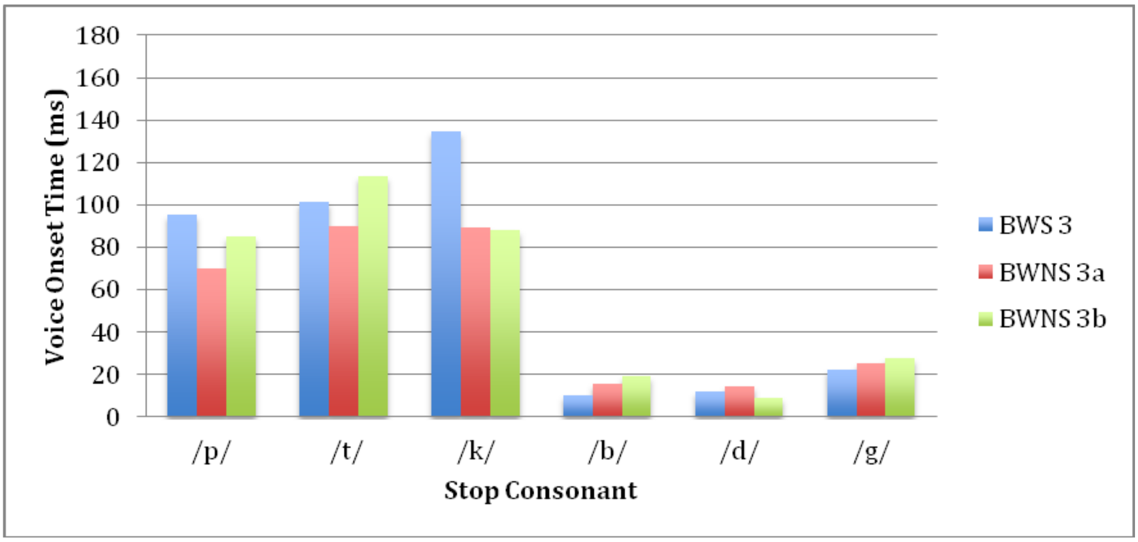

Figure 3c

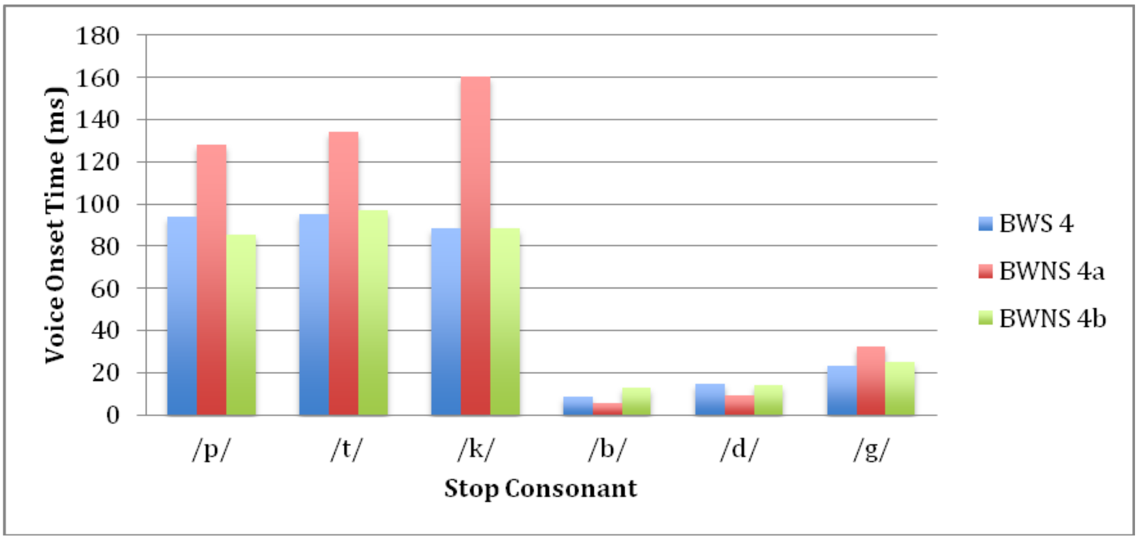

Figure 3d

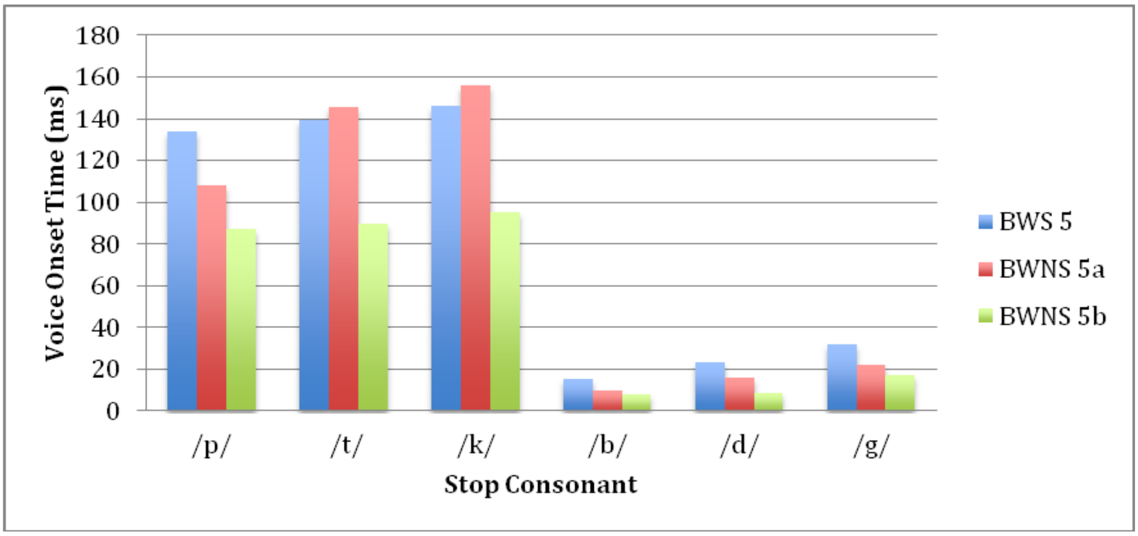

Figure 3e

Figure 3. Mean VOT values for the BWS and BWNS participants for production of Mandarin stop consonants.

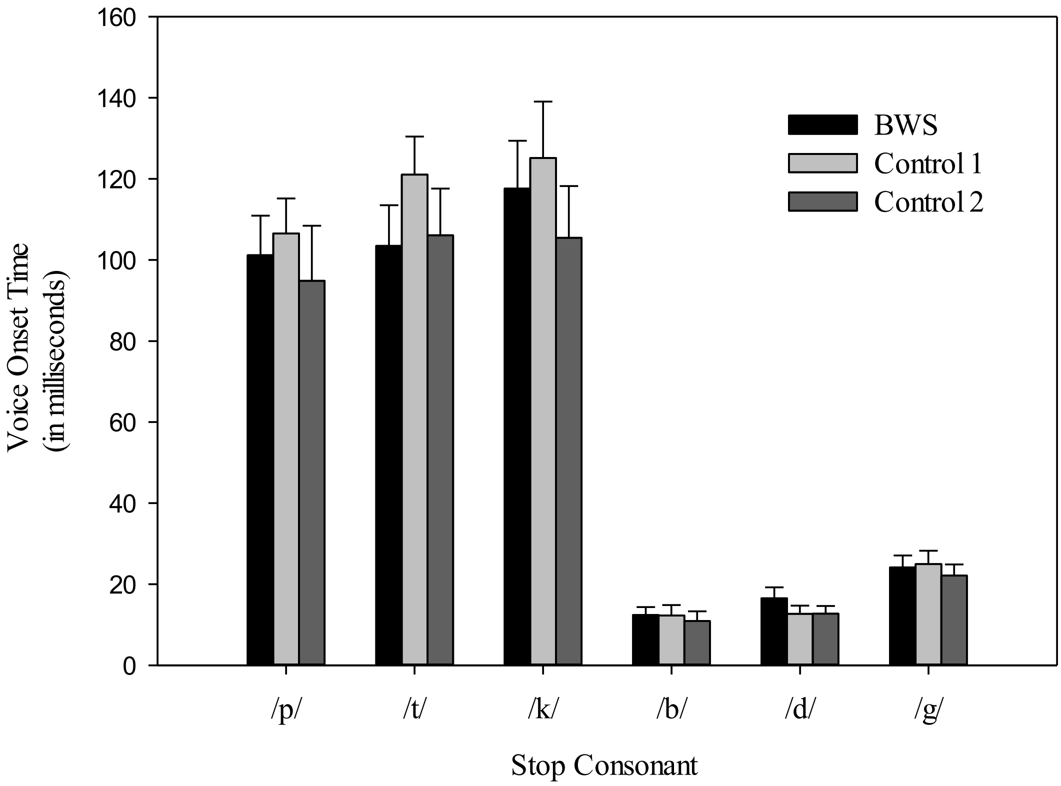

Figure 4. Mean VOT values for the BWS and BWNS Control group 1 and Control group 2 participants for production of Mandarin stop consonants. The error bars show the standard error.

English

The results of the VOT analysis for each BWS participant and the BWNS controls are displayed in Figures 5a-5e. For each of the five BWS participants, there was a clear difference in the VOT for voiceless stops (/p/, /t/, /k/) compared to voiced stops (/b/, /d/, /g/) in English. For BWS 1 (English-dominant), the VOT of /t/ compared to both BWNS controls was shorter while the VOT of /p/ and /k/ were longer than BWNS 1a but shorter than 1b. For BWS 1, the VOT of voiced stop consonants were slightly longer than both BWNS controls (see Figure 5a). BWS 2 showed a more consistent pattern in the production of VOTs than BWS 1 in english. All voiceless stop consonants produced by BWS 2 were noticeably shorter than both BWNS controls. For BWS 2 in English, voiced stop consonants /d/ and /g/ were longer than both BWNS controls with the exception of /b/ having a marginally shorter VOT (see Figure 5b). For BWS 3 (Mandarin-dominant), the VOT of /p/ and /t/ were shorter and the VOT of /k/ was similar to both BWNS controls (see Figure 5c). Voiced stop consonants produced by BWS 3 in English had a longer VOT for /b/ when compared to both controls. The VOT of /p/ and /d/ for BWS 4 appeared similar to BWNS 4a but longer in duration compared to BWNS 4b (see Figure 5d). For BWS 4 in English, the VOT of /t/ and /k/ were produced shorter than one control but longer compared to the other control. Voiced consonant /b/ was similar in VOT across BWS 4, BWNS 4a and 4b. Lastly for BWS 5, the VOTs of /p/, /t/, /k/ and /g/were longer when compared to both controls. The VOT of /d/ produced by BWS 5 was shorter compared to BWNS 5a but markedly longer than BWNS 5b (see Figure 5e).

Figure 6 shows the average VOT measures across different English stop consonants for each of the three participant groups. As in Mandarin as previously reported, voiced stops also showed a shorter VOT than voiceless stops in English (see Figure 6). Specifically, the average VOTs for the English /b/, /d/ and /g/ were 10.85 ms, 20.40 ms, and 32.04 ms respectively while those for the English /p/, /t/, and /k/ were 87.08 ms, 101.20 ms, and 113.60 ms respectively. For the BWNS group 1, the average VOT for English /b/, /d/, and /g/ were 9.16 ms, 20.60 ms, and

31.00 ms respectively while those for English /p/, /t/, and /k/ were 87.72 ms 124.20 ms, and 111.96 ms respectively. For the BWNS group 2, the average VOT for the English /b/, /d/, and /g/ were 8.80 ms, 9.56 ms, and 26.16 ms respectively while those for the English /p/, /t/ and /k/ were 92.05 ms, 110.36 ms and 112.99 ms respectively.

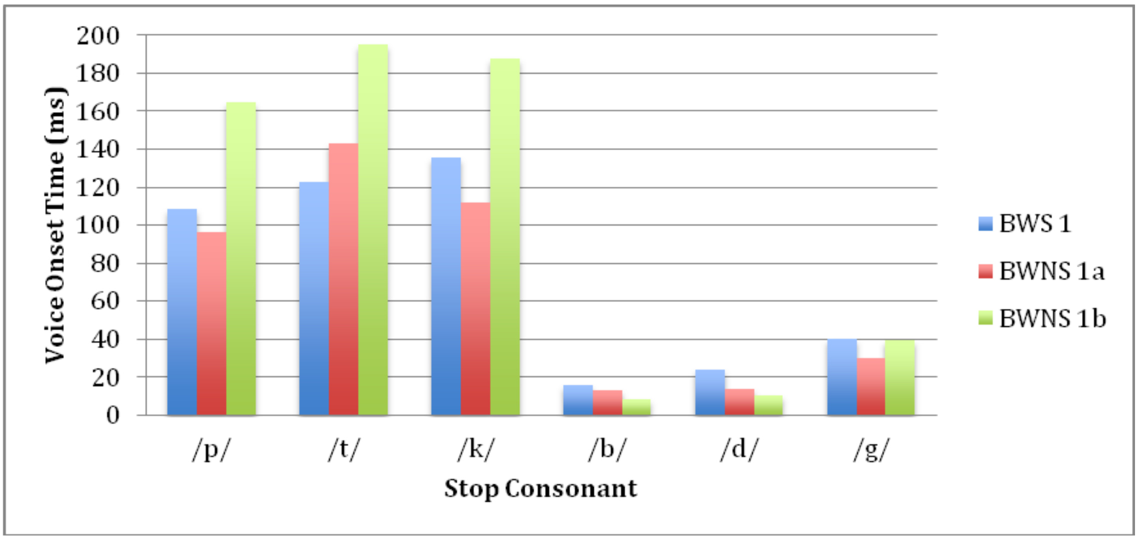

Figure 5a

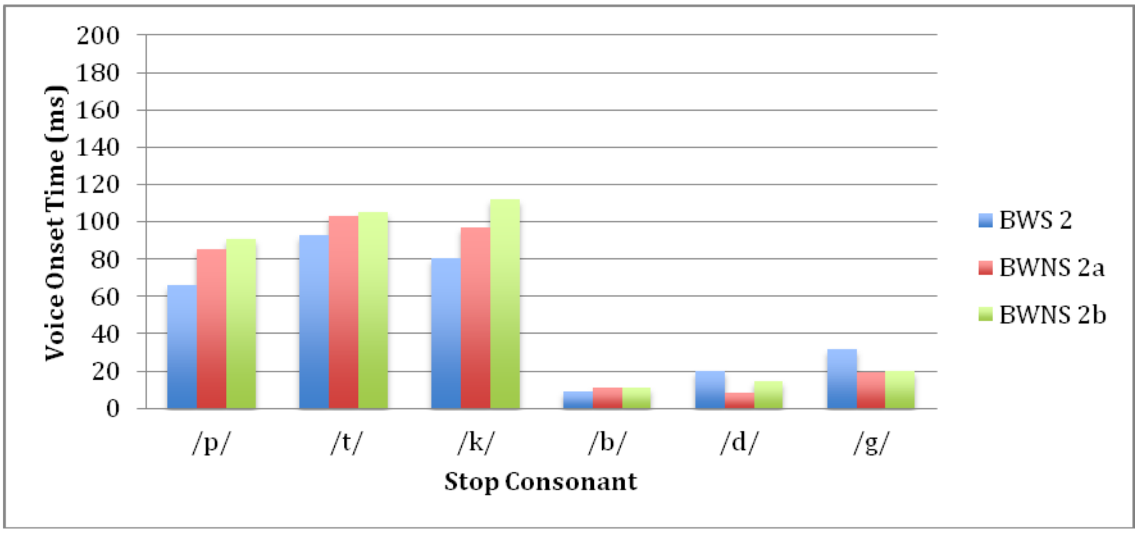

Figure 5b

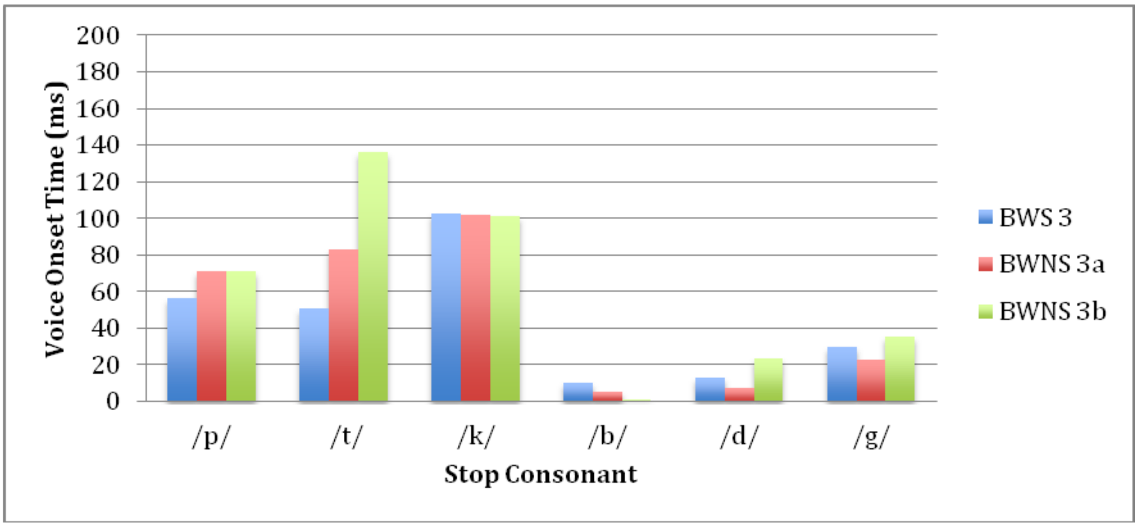

Figure 5c

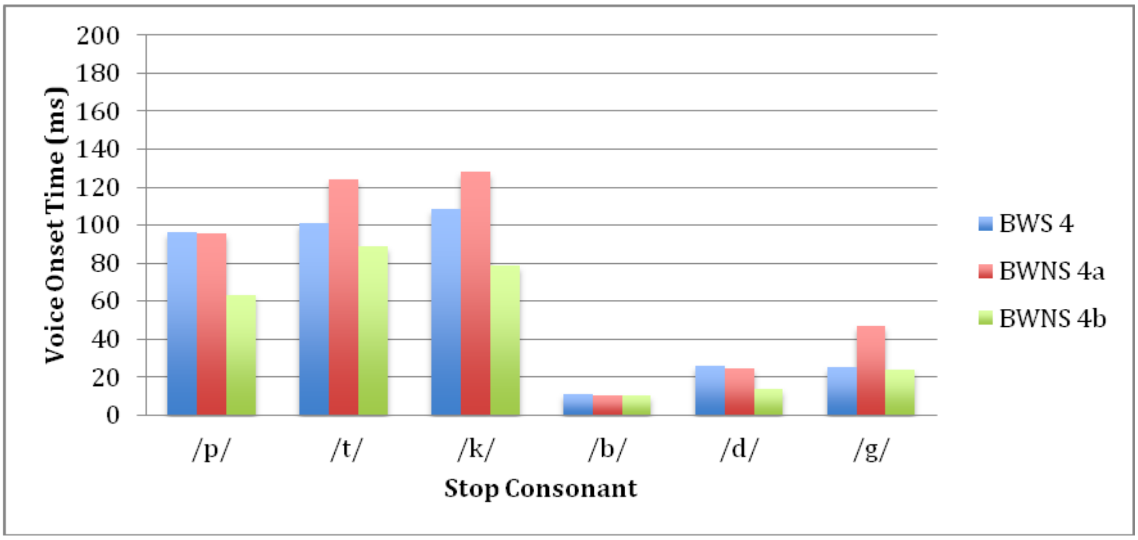

Figure 5d

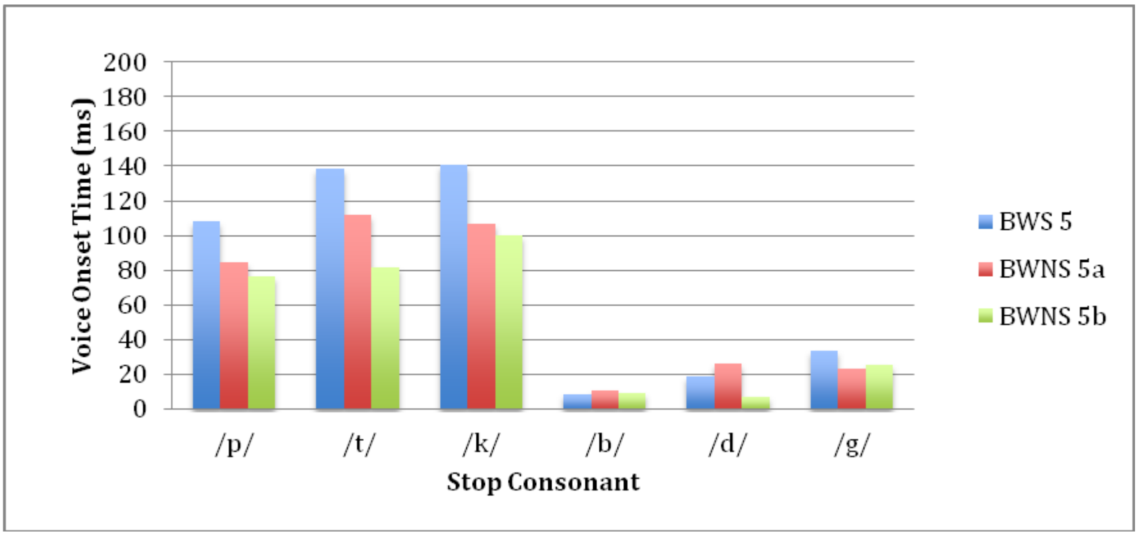

Figure 5e

Figure 5. Mean VOT values for the BWS and BWNS participants for production of English stop consonants.

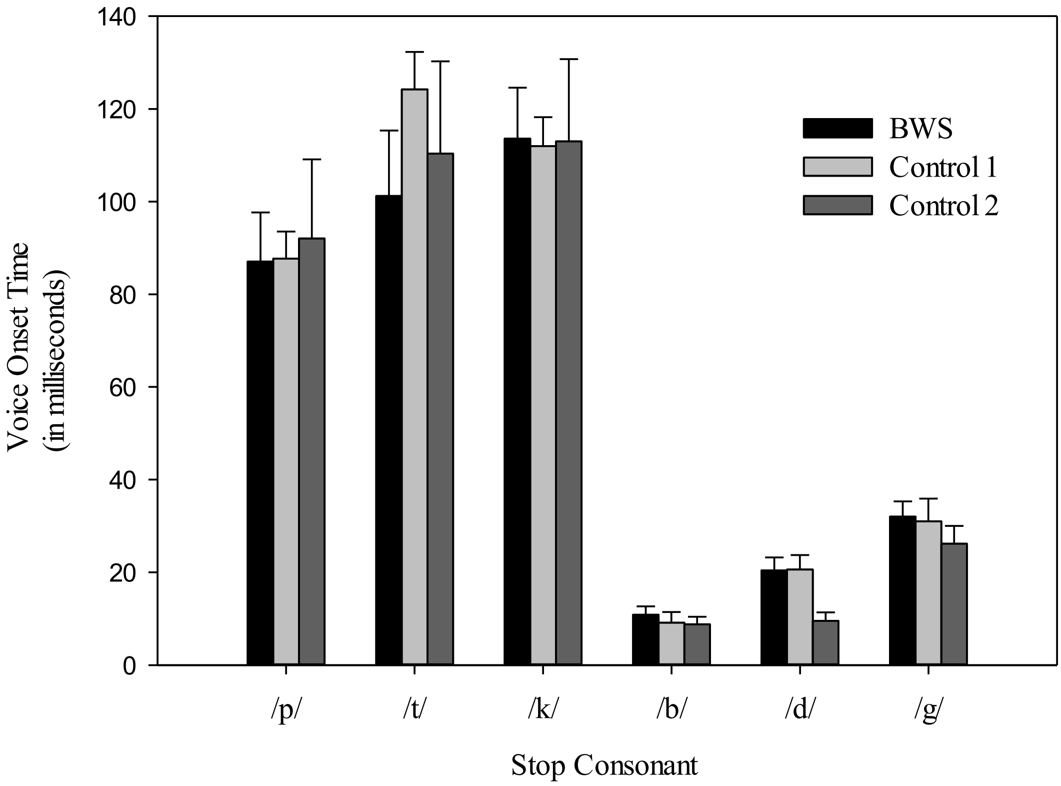

Figure 6. Mean VOT values for the BWS and BWNS Control group 1 and Control group 2 participants for production of English stop consonants.

To evaluate whether VOT varied by language type (Mandarin & English), speaker group (BWS & BWNS), as well as according to place of articulation (bilabial, alveolar, & velar), and voicing condition (voiced & voiceless), a four-way mixed model ANOVA was performed. Speaker group was treated as the between-groups factor and language type, place of articulation, and voicing condition treated as the within-groups factors. Results are shown in Table 4. As expected, there was significant difference in regard to place of articulation, and voicing. More importantly, there were no significant differences in regard to VOT production between the BWS and BWNS groups for Mandarin and English stop consonants.

Table 4. Summary table for the four-way (3 speaker groups X 2 languages X 3 places of articulation X 2 voicing conditions) Mixed Model conducted on voice onset time (VOT).

	F	Hypothesis df	Error df	p	h_p^2
Speaker Group (S)	0.280	2	12	0.761	0.045
Language (L)	0.203	1	12	0.660	0.017
Place (P)	40.905	2	24	< 0.001*	0.773
Voicing (V)	195.083	1	12	< 0.001*	0.942
S X L	0.256	2	12	0.778	0.041
S X P	1.197	4	24	0.338	0.166
S X V	0.195	2	12	0.826	0.031
L X P	11.073	2	24	< 0.001*	0.480
L X V	1.802	1	12	0.204	0.131
P X V	6.610	2	24	0.005*	0.355
S X L X P	2.344	4	24	0.084	0.281
S X L X V	1.060	2	12	0.377	0.150
S X P X V	2.042	4	24	0.120	0.254
L X P X V	2.140	2	24	0.140	0.151
S X L X P X V	0.269	4	24	0.895	0.043

* Significant at the 0.05 level.

Adaptation Effect

Mandarin

The results of the measurement of stuttering adaptation for each of the BWS participants are displayed in Figure 7. Across the five participants, the number of disfluencies during Reading One ranged from zero to eight and averaged 3.4 disfluencies for the BWS group. The number of disfluencies identified during Reading Five ranged from zero to two and averaged 0.6 disfluencies for the BWS group. The adaptation score for the five BWS participants ranged from 0% to 100% and averaged 68.2% for the BWS group.

English

The results of the measurement of stuttering adaptation for each of the BWS participants are displayed in Figure 8. Across the five participants, the number of disfluencies during Reading One ranged from one to six and averaged three for the BWS group. The number of disfluencies identified during Reading Five ranged from zero to two and average 0.6 disfluencies for the BWS group. The adaptation score for the five BWS participants ranged from 33% to 100% and averaged 83.2% for the BWS group, which was higher than the average for Mandarin.

Mandarin vs. English

To determine whether stuttering adaptation differed between Mandarin and English, a paired t-test was performed on the average adaptation scores for each language. The results of the paired t-test were no significant language effect on stuttering adaptation rate ($t = -0.67$, $df = 4$, $p = 0.54$), indicating that the amount of adaptation was similar for both languages.

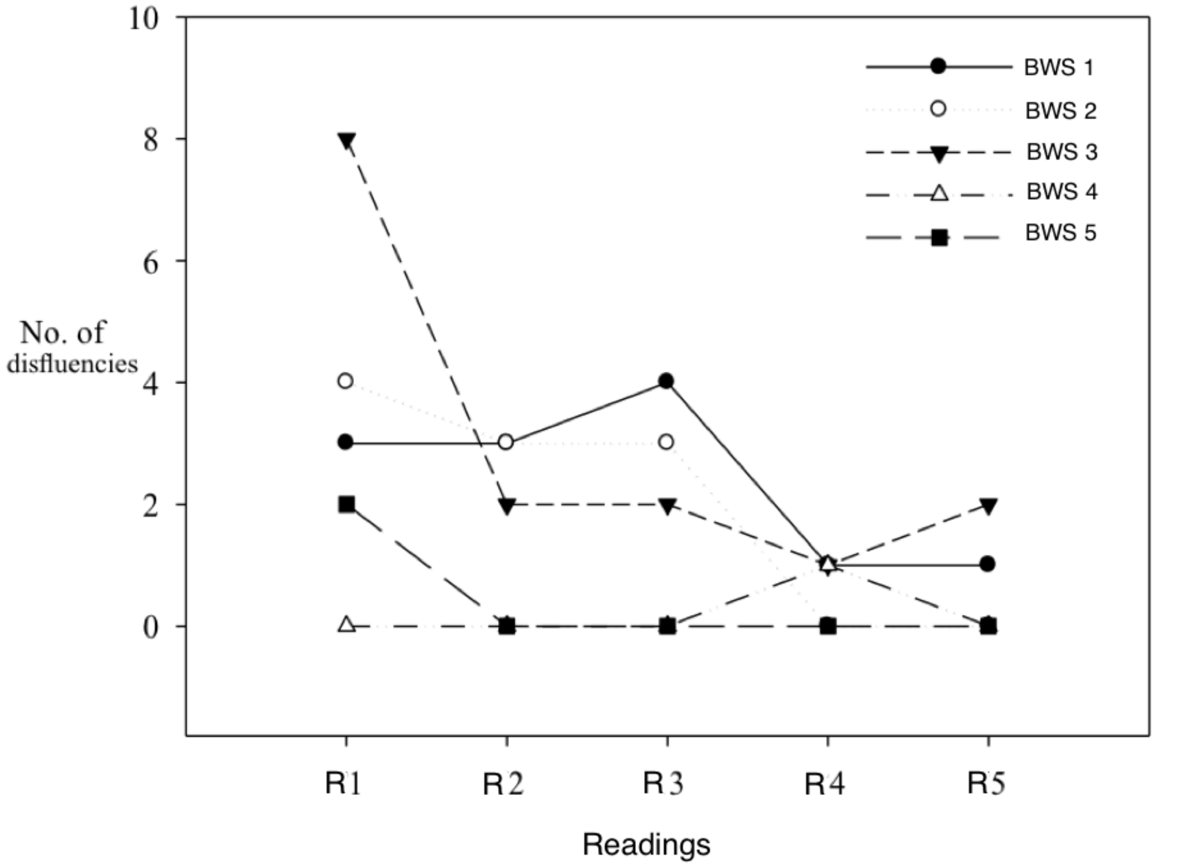

Figure 7. The number of disfluencies across five repeated readings of the Rainbow Passage in Mandarin for bilinguals who stutter (BWS).

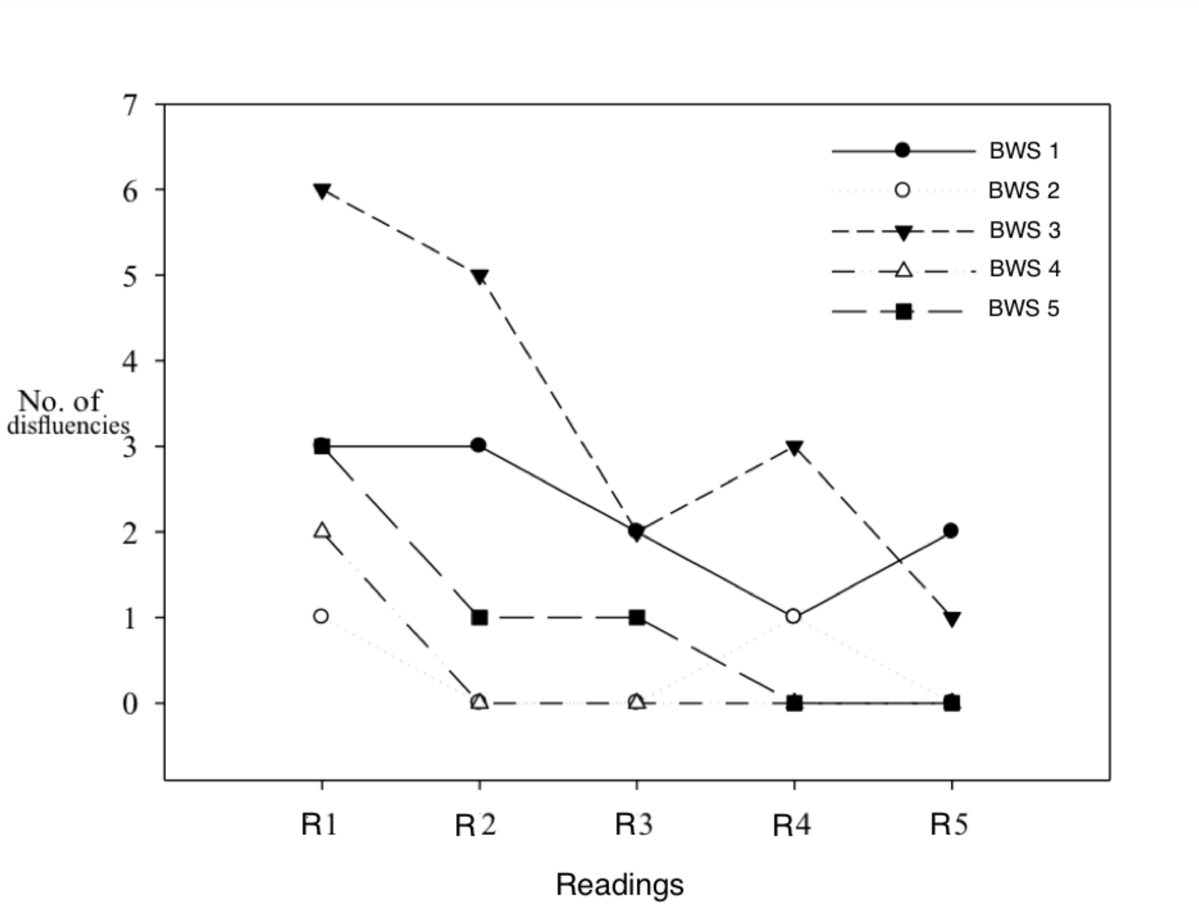

Figure 8. The number of disfluencies across five repeated readings of the Rainbow Passage in English for bilinguals who stutter (BWS).

Summary of Results

The primary results of the present study were as follows:

(1) No difference was found between BWS and BWNS for speaking rate.

(2) For the majority of participants (BWS & BWNS), speaking rate in Mandarin was faster compared to English

(3) There was no difference found between the VOTs of BWS and BWNS.

(4) For all participants, VOT for voiceless stop consonants were longer in duration compared to voiced stop consonants.

(5) No difference was found in stuttering adaptation between Mandarin and English readings of the Rainbow Passage for the BWS participants.

Discussion

The purpose of the present study was to measure selected acoustic features of speech production in fluent and disfluent English-Mandarin bilinguals. These acoustic measures were then used as estimates of speech motor control. Four research questions were posed and the discussion pertaining to each of these questions is presented below.

Research Question 1: Do BWS stutter more severely in one language compared to the other?

In the present study, the severity of stuttering exhibited by each of the BWS participants was determined using the SSI-3 (Riley, 1972). Based on the overall scores derived from the SSI-3, it was found that four of five participants had the same stuttering severity in both languages. The remaining BWS participant showed a high severity in the less dominant language. On the overall basis of the SSI-3, it would appear that the present group of BWS did not show a greater severity of stuttering in one language. However, another estimate of stuttering severity to consider is the percentage of syllables stuttered (%SS). Based on this measure, it was noted that all participants had a higher %SS in the less dominant language in the combined speaking and reading tasks of the SSI-3 (see table 2).

There are a number of studies examining the severity of stutter exhibited in both language samples of BWS. Studies that have found more stuttering in the less proficient language include Jankelowitz and Bortz (1996), Roberts (2002), and Schäfer and Robb (2012). On the other hand, Jayaram (1983), Howell et al. (2004), and Shenker et al. (1998) found more stuttering in the more proficient language. In addition, Nwokah (1988) and Roberts (2002) reported that a number of their participants showed no significant differences between stuttering in more proficient and less proficient languages.

The varied influence of language proficiency on the amount of stuttering observed across languages in BWS might be attributable to the different terms that have been used to describe the relationship between languages in BWS. These terms include “primary language”, “predominant language”, “more proficient language, and “native language” (Jayaram 1983; Jankelowitz & Bortz, 1996; Scott Trautman & Kelly, 2000). If these terms are not used and applied consistently across studies, it become problematic in determining whether language proficiency or language dominance was measured. Unlike language proficiency, which measures a person’s command of grammar, vocabulary and pronunciation, language dominance reflects the differences in processing each of the two languages (Birdsong, 2006). According to Lim et al. (2008b), “a bilingual may have native-like proficiency in two languages but still consider on language to be better than the other”. In the present study, the methodology was similar to that used by Schäfer and Robb (2012). In their study of bilingual German-English speakers, they found that severity of stuttering did not differ based on SSI-3 but based on calculation of %SS, they found more stuttering in L2. The present study aligned nicely with those of Schäfer and Robb (2012).

A possible reason that SSI-3 did not reflect significant difference in stuttering severity of BWS in this study can be explained by a limitation in the design of this particular instrument. Lewis (1995) stated that the measurement of physical concomitants (as required of the SSI-3 instrument) was subjective and unreliable between clinicians. Furthermore, it appears that the %SS between participants can be obscured when calculating the Task Scores subtest of the SSI-3. For example, Lewis found that in the speaking task of the SSI-3, individual participants differed in the %SS, ranging from 13% to 17% yet both their scores were converted to the same Task Score of 8. Moreover, the lack of descriptions for the calculations of raw scores and ratings may have contributed to the lack of sensitivity of this tool. This seemed to also be the case in the present study.

Although there are various reports regarding the amount of stuttering exhibited by BWS, the majority of studies indicate that more stuttering is likely to occur in the less proficient language (Scott Trautman & Keller, 2000). The results of the present study provide additional support that language proficiency is linked to the amount of stuttering exhibited by BWS. In concert with the results of Lim et al. (2008a), the results found in this present study contribute further evidence to support the use of language dominance as a means of determining the relationship between languages, as well as supporting the explanation of why stuttering may be uneven across languages in bilinguals.

Research Question 2: Do BWNS and BWS exhibit the same speaking rate?

Overall, there was no difference observed between BWS and BWNS in their speaking rate. Both groups spoke Mandarin at a rate of approximately 5.0 sps, and both groups spoke English at a rate of approximately 4.5 sps. From past research, overall speaking rate for adults who stutter has been found to be substantially slower than normally fluent speakers. Bloodstein (1944) found that adults who stutter had an overall speaking rate of 122.7 words per minute (wpm) and Walker (1988) found that normal fluent speakers spoke at approximately 170 wpm. This finding has been confirmed by other researchers who have found that adults and children who stutter tend to speak more slowly than fluent speakers in conversation and oral reading (Andrews, Howdie, Dozsa, & Guitar, 1982; Meyers & Freeman, 1985). A possible reason for the lack of difference between BWS and BWNS in the present study compared to past studies is in regard to the method of speaking rate calculation. Past studies have calculated overall speaking rate from speech samples that includes pauses and/or possibly imperceptible disfluencies. This measure of speaking rate reflects verbal output rather than the timing of articulatory gestures (Costello & Ingham, 1984). The present study calculated speaking rate based on exclusion of any pauses exceeding 250ms in duration. This measure was more likely to reflect articulation rate rather than speaking rate. By excluding or removing pauses and possible imperceptible disfluent segments from the timed speech sample, the measure provided a better estimate of speech execution time (Hall, Amir & Yairi, 1999). By looking at articulation rate, the measurement of duration reflects the performance of the speech production mechanism, which is of particular value for the investigation of the temporal aspects of motor speech. On the basis of this measure, it would seem that BWS and BWNS exhibit the same speaking rate.

An interesting finding in the present study was that Mandarin was spoken at a significantly faster speaking rate compared to English. This was consistent across the majority of BWS and BWNS participants, regardless of language dominance. The observations do not support the previous bilingual research by Chakraborty et al. (2008). These researchers found that among bilinguals, speaking rate was faster for the more proficient language compared to the less proficient language. A similar conclusion was reached by Guion, Flege, Liu, and Yeni-Komshian (2000) who found native speakers of Italian and Korean learning English (as L2) showed a slower speaking rate of L2 as the age of learning increases. A later study by Trofimovich and Baker (2006) found identical results for Korean-English bilinguals and supported the finding of Guion et al. (2000), whereby speech rate was related to age of first extensive exposure to the language. This behavior was attributed to processing, encoding and retrieval of phonological information, and difficulties in articulation of L2 speech (Munro & Derwing, 1995, 2001).

In the present study, three of the BWS and six of the BWNS participants showed dominance in Mandarin, while two BWS and four BWNS participants showed language dominance in English. In spite of these differences in language dominance, speaking rate was still faster in Mandarin. One possibility to consider is that some languages, such as Mandarin, may simply be spoken at a faster rate compared to other languages, such as English. It is well known that speaking rate varies with different dialects of English. To list a few, adult speakers of American English speaking rate were found to range from 4.16 to 5.91 sps (Robb, Maclagen & Chen, 2004; Eady, 1982). Adult speakers of British English were found to have a rate ranging from 4.33 to 6.21 sps (Tauroza & Allison, 1990, Deterding, 2001). Adult speakers of

New Zealand English have an overall speaking rate of 4.66 sps (Robb et al., 2004). Adult speaker of Singapore English have an overall speaking rate of 6.37 sps (Deterding, 2001). Likewise, speaking rate in Mandarin is also varied and has been found to range from 4.73 sps to as high as 10.66 sps (Wu 1980, Eady 1982).

Based on report of speaking rate in these past studies, it seems plausible that language dominance was not a major factor in the observed difference between Mandarin and English. Rather, it seems likely that Mandarin is spoken at a faster rate than English. There is no evidence in the present study to suggest language dominance influences speaking rate however, there is some indication of the influence of syllable vs. stress timing dialect difference on speaking rate for Mandarin and English. Roach (1982) measured the duration of syllables of English and Russian and compared these measures with those derived from French and Yoruba. The author failed to find any consistent overall distinction in the timing of the first group of supposedly stress-timed languages against the second group of syllable-timed languages. Dauer (1983) also found no difference in syllable duration between Spanish and English, attributing the perceived rhythmic difference to the syllabic structure of the languages rather than in their timing. The explanation was that Spanish has far more CV syllables than English. It has however, been shown that for syllable-timed speech, the larger the number of syllables, the longer the duration of speaking rate; whereas for stressed-time languages, the number of syllables do not affect speech duration but rather it is the number of stress-syllables that influences speech duration (Nishihara & Van de Weijer, 2010). A likely reason for the difference in Mandarin and English speaking rate found in the present study may also be due to the way in which vowels alternate with consonants. Ramus, Nespor and Mehler (1999) reported that when observing stress-timed to syllable-timed, the syllabic structures tend to get simpler and the simple syllables imply the presence of proportionately greater vocalic spaces. Subsequently, the production of vowels would occupy less time in the flow of speech in stress-timed languages than syllable-timed languages. This would translate to a faster speaking rate.

Research Question 3: Do BWS and BWNS differ in VOT?

There was no difference in VOT observed between BWS and BWNS. This was consistent with previous research by Metz, Conture, and Caruso (1979), and Watson and Alfonso (1982), who found no significant group differences in the fluent speech of between people who do and do not stutter. There was also no difference in each participant's English and Mandarin VOT between languages and between language dominance. A similar result was obtained by Lauter and Lu (1987) who observed that English and Mandarin are similar in range of VOT with clear distinctions between voice/voicedless stops. Shimizu (2011) also found minimal differences in VOT values for Mandarin and English bilinguals. Past research examining the VOT for English stops reports VOTs ranging from 42 to 58 ms for /p/, 64 to 70 ms for /t/, 62 to 80 ms for /k/, 1 to 15 ms for /b/, 5 to 21 ms for /d/ and 21 to 27 ms (Lisker & Abramson 1964; Klatt, 1975; Docherty, 1992). Mandarin consists of aspirated voiceless stops and non-aspirated voiceless stops. For the purpose of the present study, /b/, /d/ and /g/ VOT production in Mandarin were classified as non-aspirated stops. Past research reports of VOT in Mandarin have found VOTs ranging from 75 to 100 ms for /p/, 71 to 99 ms for /t/, 92 to 110 ms for /k/, 14 to 18 ms for non-aspirated /p/, 16 to 19 ms for non-aspirated /t/ and 27 to 28 ms for non-aspirated /k/ (Chao, Khattab and Chen, 2006; Rochet & Fei, 1991; Chao & Chen, 2008). The VOT values obtained in the present study for the voiceless aspirated Chinese stops are somewhat higher than the data reported in previous studies, similar for voiceless English stops. Both English voiced stops and non-aspirated Mandarin stops were in the same range except for /b/ in Mandarin and /d/ in English which appeared to have a lower mean.

There is a past report that bilinguals tend to show altered (either converged or exaggerated) VOT values in one or both of their languages relative to those of monolingual speakers. Sancier and Fowler's (1997) case study of a Portuguese-English bilingual suggested that a bilingual's VOT values are not fixed; rather they tend to drift according to the ambient speech environment. Specifically, they found that VOTs are always shorter for productions in Brazilian Portuguese than in English but the VOTs produced in both languages became shorter after a several month stay in Brazil than after a several month stay in the United States. They labeled the phenomenon observed in their study as "gestural drift" because the gradient changes to VOT was observed in both the speaker's L1 (Portuguese) and L2 (English). Some studies of initial stop production in bilinguals have suggested that production results for bilinguals conform with monolingual results (Williams, 1977), others have argued that production is a reflection of language a dominance with little phonological interference from the weaker language (Caramazza, Yeni-Koshian, Zurif & Carbon, 1973; Mack, 1989). Others still postulate that only bilinguals who have learned their second language early will establish separate phonetic categories for the two languages (Flege, 1991).

Based on the results obtained in the present study, the speech motor control surrounding stop consonant production (as inferred via VOT) does not appear to differ between BWS and BWNS participants. It is possible that VOT may not be sensitive to speech motor control in bilinguals due to the complicated learning process and language experience of each individual. Any differences in speech motor control between these two groups may only be detected by applying more robust measurements such as physiological changes in movement parameters (Chakraborty et al., 2008).

Research Question 4: Do BWS show differences in stuttering adaptation across languages?

There was no significant difference found in the amount of stuttering adaptation in English and in Mandarin for the BWS participants. For both languages, clear adaptation was observed; however slightly more adaptation was observed in English. Although this difference was not confirmed statistically, it would suggest that BWS benefited more from the motor rehearsal of repeated reading of the same passage in English than in Mandarin. The findings of the adaptation effect are consistent to that a number of past studies by Frank and Bloodstein (1971), Max, Caruso, and Vandevenne (1997), Max and Caruso (1998) who found individuals who stutter show a decrease in stuttering frequency of approximately 50% across 5 repeated readings of the same material. These researchers concluded that the increase in fluency during repeated reading appeared to be related to oral rehearsal of the motor plan, or in other words, motor learning. Another reason for more adaptation seen in English could be due to the higher proportion of Mandarin dominant vs. English dominant participants. In the present study, the ratio of Mandarin to English dominant BWS was 3:2. Jankelowitz and Bortz (1996) mentioned that greater adaptation is seen in the less proficient language and it may be due to the present population of participants with English as their less dominant language that a difference in adaptation effect between languages surfaced.

Evans (2002) found evidence from his study of two bilinguals, including one Englis-Polish and one English-French bilingual, that both language proficiency and a change of oral motor plan affect stuttering frequency. In Evans' (2002) study, participants were asked to read passages consecutively five times in L1 then five times immediately in L2. The reading process was also repeated in the opposite order from L2 to L1. One participant (Participant 1) demonstrated no adaptation in English (L2) but high level of adaptation in Polish (L1) regardless of the reading order of the language. Between reading five and six (i.e., when the participant switched language), it was observed that there was an increase in stuttering from L2 to L1. This observation might have given the indication of an influence of oral motor change, but on closer examination, there was a decrease in stuttering when the participant read from L1 to L2. Consequently, Evans was unable to relate oral-motor plan as the primary contributor to an increase in the amount of stuttering. The differences in stuttering between the readings were attributed to linguistic factors such as language proficiency. This suggestion was supported by the participant's description of English as her more "comfortable" language.

The result from the other participant (Participant 2) in Evans' (2002) study indicated that a change in motor plan affects stuttering frequency. Participant 2 also reported being more comfortable speaking English (L2) compared to French (L1). It was found that there was increase in stuttering when he read between languages whether it was English-to-French or French-to-English. This consistent finding is indicative of a change in motor plan. An important finding in the study was that in both participants, similar amounts of stuttering in the final readings of each language across reading sets were shown despite differences in initial amounts of stuttering in each language across reading sets. It appears that differences in the initial amount of stuttering in each language did not alter the final amount of stuttering in the last readings of the adaptation series. This suggests that if varying degrees of proficiency exists between two languages, both languages can adapt to a similar level when successive oral readings of the same material is allowed.

Limitations

Although the results of the present study are indicative of no significant differences in the motor control of BWS and BWNS, there are some limitations to the present study that need to be considered. One of the drawbacks of this study was the sample size of BWS and BWNS participants. The present study examined 5 male BWS of which four were adults and one was a child. Although the sample size was small, it is important to consider the results in the context of past studies examining BWS. These studies have ranged from a sample size of one (Jankelowitz and Bortz, 1996) to 30 (Lim, et al., 2008a), with most studies consisting of five or fewer participants. As a way of compensating for sample size of BWS participants, two control BWNS participants were matched to each BWS participant. By doing so, it was assumed that a more valid comparison of BWS to BWNS could be achieved.

Another possible limitation in the present study is related to the acoustic measurement of speech motor control. Speaking rate, VOT and adaptation were selected as measures used to infer speech motor control. Although these measures have been used extensively over the years to estimate motor control, they may not have been sufficiently sensitive to detect differences between BWS and BWNS. Acoustic measures to examine vocal tract motor control (i.e. formant frequencies) may have been more informative. In addition, physiological measures were not included in the present study. Physiological measures such as lip and jaw movements have been shown to be marginally discriminating of speech motor control in bilingual speakers (Chakraborty et al., 2008).

It is important to note that examining speech motor control in the present study was based on speakers of Mandarin and English. Such a comparison of stressed timed vs. syllable-timed language, tonal vs. non-tonal language may not have been an ideal approach to examining motor control behaviors in BWS and BWNS. An alternate approach would have been to examine BWS and BWNS who are speakers of languages derived from the same "families" (i.e. Indo-European or Sino-Tibetan). Such comparisons may detect greater differences between BWS and BWNS if speech motor control is indeed a factor in BWS.

Clinical Implications

Assessment

Assessing fluency in bilingual individuals is quite likely to involve evaluation of a language that is not familiar to the clinician. As such, speech-language therapists (SLT) are faced with a range of clinical questions such as "how can I assess a BWS?", "how can I diagnose stuttering in a foreign language?" and "which language should therapy be targeting?" Roberts and Shenker (2007) noted that there are possibly more people in the world who are bilingual compared to monolingual speakers. Therefore the likelihood of a SLT encountering a bilingual client in their career is high. Unfortunately, standard protocols for the assessment of BWS do not exist.

The results of the present study found that between languages, BWS showed differences in the overall percentage of stuttering. This finding has provided some initial guidelines for the assessment of BWS. Although stuttering has been found to be easier to detect if the language under investigation and the SLT's native language belong to the same language family, having little knowledge of a language does not mean that one cannot assess the disfluencies of a bilingual client (Van Borsel, Leahy & Britto Pareira, 2008). For example, Van Borsel & Pereira (2005) found that monolingual Dutch and Portuguese speaking SLTs were able to make similar levels of judgment of stuttering in their native and foreign language. Van Borsel et al. (2008) examined monolingual Dutch, English and Portuguese speaking SLTs in their identification of disfluencies in a foreign language. It was found that monolingual Dutch speakers performed better at identifying disfluencies in English compared to Portuguese. Monolingual English speaking SLTs performed better at identifying disfluencies in Dutch compared to Portuguese. On the other hand, monolingual Portuguese speaking SLTs did not perform as well as the monolingual speaking Dutch and English SLTs in the identification of disfluencies in Dutch and English. In other words, Dutch and the English speaking SLTs (both West Germanic languages) performed better in identifying disfuencies compared to the Brazilian Portuguese SLT's (a Romance language). This confirms the existence of a closeness of language influence when assessing stuttering.

One of the main guidelines for the assessment of BWS is that a client must exhibit stuttering-like disfluencies in the more proficient language in order to diagnose as a BWS (Van Borsel, Maes & Foulon, 2001). If a client only exhibits disfluencies in the less proficient language, these may be related to language formulation difficulties and special care needs to be taken if the language is unknown to the SLT. One way of achieving reliable judgment about the presence of stuttering in a child may be through consensus agreement between parent and clinician. For adults and children, besides assessing stuttering severity across languages, it is necessary to assess language skills, as therapy in BWS may be affected by supporting language skills (Conture & Curlee, 2007). It is important to compare stuttering patterns, language dominance, and language proficiency levels in both languages in order to be able to holistically assess stuttering and create a treatment program based on the individual needs of the client.

Treatment

Based on the present findings that more stuttering is present in the less dominant language, it is important to consider both languages of a BWS in the management plan. Similar to the issues regarding the diagnosis of stuttering in BWS, there are no formal guidelines available for treatment. The main issue for SLT remains, namely which language should be targeted in therapy? Roberts and Shenker (2007) claimed that ideally, a BWS should be treated in both languages. However, it is unlikely that a BWS would be seen by an SLT who is also fluent in all of the languages spoken by the client. Therefore, a prevailing guideline for the treatment of BWS is that therapy should be provided in the language that is used most often by the client.

The present study also found no significant differences in the speaking rate, VOT and adaptation effect of BWS and BWNS. This implies that speech motor control in BWS and BWNS may be similar. There is an absence of research examining treatment efficacy in BWS, however, it is important to note that several evidence-based treatments involving speech motor control (e.g., prolonged speech) have proven to be successful in monolingual English-speaking people who stutter. Moreover, treatments involving speech motor control have also been successfully used in other languages (Roberts and Shenker, 2007). Based on the present results, it appears plausible to use the same motor-based treatment approach in both languages spoken by a BWS.

Directions for future research

There is still much to learn about bilingualism and stuttering, in particular BWS who speak Asian languages. It is unknown how many people who stutter are bilingual, but it is safe to estimate that at least 500,000 people in the United States alone are BWS. Most current models of stuttering are multifactorial and factors that interact to cause stuttering include genetics, environment, language skills, motor skills and temperament (Conture & Curlee, 2007). In bilinguals, genetics, motor skills, and temperament are presumably constant across languages. It is extremely unlikely that a bilingual will stutter in one language and not the other (Van Borsel, Maes and Foulon, 2001).

From the studies reviewed, it seems clear that the role of language proficiency on stuttering behavior in bilinguals requires further investigation. The diversity of meanings in the literature regarding language proficiency and language acquisition makes it difficult in particular to support or refute past results. It appears that the terminologies of language acquisition have been confused with the terminologies of language proficiency. It is said that bilinguals that may be proficient in two languages, have competence that may not be equivalent across domains (home vs. classroom/workplace) (Grosjean, 1985). Roberts and Shenker (2007) described bilingualism as a continuum and therefore language acquisition does not necessarily refer to the proficiency level spoken by an individual. Language proficiency is also often confused with language dominance. Birdsong (2006) suggested that dominance in psycholinguistic terms usually indicate a difference in processing ability between L1 and L2, whereas proficiency is viewed in terms of the mastery of syntax, vocabulary, and pronunciation of a language. Moreover language use and the nature of bilingualism often change across the lifespan if the acquisition of one language is interrupted and insufficient, or if the learning of one language is more structured and formal because it involves reading and writing as well as speaking and listening (Hamers & Blanc, 2000). The complex patterns of language acquisition have made it difficult to ascertain which language is the dominant one. Available methods for determining language dominance in bilinguals can be separated into two categories, to assess late bilinguals such as migrant population who used a first language and then acquire a second language after immigration and to assess early bilinguals, those exposed to both languages at a young age (Lim et al., 2008b). Subsequently, subjective suggestions alone such as a participant's perception of which language he/she feels more proficient in, or an objective measure of language abilities is an inadequate determination of language proficiency. Bilinguals can have almost native-like proficiency in both languages but may consider one language to be better than the other. Alternatively, they may be dominant in one language but not necessarily highly proficient in that language. Therefore, in order to allow for clinically relevant, as well as reproducible studies, future investigations will need to incorporate valid, reliable, and efficient language dominance tests, as well as proficiency tests. More importantly, it has been previously suggested that the severity and type of stuttering behaviors may be different across a bilingual's two languages and this may be influenced by language dominance (Lim et al., 2008a) and language proficiency (Evans, 2002).

Summary and Conclusion

Speaking rate did not differ between BWS and BWNS but speaking rate was found to be significantly faster in Mandarin than in English. Likewise, the VOT production of BWS and BWNS did not differ, regardless of language type. In addition, stuttering adaptation was found to be similar across languages. Stuttering severity was found to be higher in the less dominant language than the dominant language when using %SS as a measure. The results of this study suggest that speech motor control in BWS and BWNS is similar, at least based on the present set of measures. This suggests that the use of evidence-based speech motor approaches to therapy for monolingual speakers who stutter may also be used for BWS. Future bilingual research evaluating languages dominance and other measures of speech motor control is a likely direction in unraveling speech motor control in bilinguals who stutter.

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Appendices

Appendix 1

Self-report questionnaire to determine language dominance in participants

Appendix 1

Department of Communication Disorders

UNIVERSITY OF CANTERBURY
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DETERMINING LANGUAGE DOMINANCE IN ENGLISH–MANDARIN BILINGUALS:
A SELF-REPORT CLASSIFICATION TOOL

Date: ______________________________

Nationality: ______________________________

Gender (please circle): M / F ______________________________

Country of Birth: ______________________________

Date of Birth: __________ **Age:** ______ **years and** ______ **months:** __________

Highest Qualification: ______________________________

No. years of formal instruction in: English= ______ **Mandarin=** ______

No. of years of exposure to: English= ______ **Mandarin=** ______

Handedness: Left/ Right ______________________________

A. Understanding

Please write down a number to show which languages you **UNDERSTAND BEST.** For example, if you understand English best, put the number "1" next to the word "English." If you understand Mandarin second best, put a number "2" next to the word "Mandarin." If you cannot understand any of the languages, put a "0" next to that language.

Also, please report the age at which you started to **UNDERSTAND** each of the languages that you know. For example, you may have started to hear and understand Mandarin at home (age = 1 year) but you did not start hear and understand English until kindergarten (age = 5 years). If you cannot remember exactly, make an educated guess.

Language	Ranking	Age of First Exposure
English		
Mandarin		
Others: (Specify)		
Others: (Specify)		

Please **circle** a number on the rating scale below to indicate the proficiency/competency with which you can **CURRENTLY UNDERSTAND** each language. You can rate your- self in comparison to the general population in Singapore. **DO NOT USE** half-points (e.g., 3.5).

How proficient are you in **understanding** English?

Very few words   Native proficiency

1 2 3 4 5 6 7

How proficient are you in **understanding** Mandarin?

1 2 3 4 5 6 7

How proficient are you in **understanding** other languages (specify ________)?

1 2 3 4 5 6 7

How proficient are you in **understanding** other languages (specify ________)?

1 2 3 4 5 6 7

B. Speaking

Please write down a number to show which languages you **SPEAK BEST.** For example, if you speak English best, put the number "1" next to the word "English." If you speak Mandarin second best, put a number "2" next to the word "Mandarin." If you cannot speak any of the languages, put a "0" next to that language.

Also, please report the age at which you started **SPEAKING** each of the languages that you know. For example, you may have started speaking Mandarin at home (age = 1 year) but you did not start speaking English until kindergarten (age = 5 years). If you cannot remember exactly, make an educated guess.

Language	Ranking	Age of First Exposure
English		
Mandarin		
Others: (Specify)		
Others: (Specify)		

Please **circle** a number on the rating scale below to indicate the proficiency/competency with which you can **CURRENTLY SPEAK** each language. You can rate yourself in comparison to the general population in Singapore. **DO NOT USE** half-points (e.g., 3.5).

How proficient are you in **speaking** English?

Very few words   Native proficiency

1 2 3 4 5 6 7

How proficient are you in **speaking** Mandarin?

1 2 3 4 5 6 7

How proficient are you in **speaking** other languages (specify ________)?

1 2 3 4 5 6 7

How proficient are you in **speaking** other languages (specify ________)?

1 2 3 4 5 6 7

C. Reading

Please write down a number to show which languages you **READ BEST.** For example, if you read English best, put the number "1" next to the word "English." If you read Mandarin second best, put a number "2" next to the word "Mandarin." If you cannot read any of the languages, put a "0" next to that language.

Also, please report the age at which you started **READING** each of the languages that you know. For example, you may have started reading Mandarin at home (age = 1 year) but you did not start reading English until kindergarten (age = 5 years). If you cannot remember exactly, make an educated guess.

Language	Ranking	Age of First Exposure
English		
Mandarin		
Others: (Specify)		
Others: (Specify)		

Please **circle** a number on the rating scale below to indicate the proficiency/competency with which you can **CURRENTLY READ** each language. You can rate yourself in comparison to the general population in Singapore. **DO NOT USE** half-points (e.g., 3.5).

How proficient are you in **reading** English?

Very few words Native proficiency

1 2 3 4 5 6 7

How proficient are you in **reading** Mandarin?

1 2 3 4 5 6 7

How proficient are you in **reading** other languages (specify ________)?

1 2 3 4 5 6 7

How proficient are you in **reading** other languages (specify ________)?

1 2 3 4 5 6 7

D. Writing

Please write down a number to show which languages you **WRITE BEST.** For example, if you write English best, put the number "1" next to the word "English." If you write Mandarin second best, put a number "2" next to the word "Mandarin." If you cannot write any of the languages, put a "0" next to that language.

Also, please report the age at which you started **WRITING** each of the languages that you know. For example, you may have started writing Mandarin at home (age = 1 year) but you did not start writing English until kindergarten (age = 5 years). If you cannot remember exactly, make an educated guess.

Language	Ranking	Age of First Exposure
English		
Mandarin		
Others: (Specify)		
Others: (Specify)		

Please **circle** a number on the rating scale below to indicate the proficiency/competency with which you can **CURRENTLY WRITE** each language. You can rate yourself in comparison to the general population in Singapore. **DO NOT USE** half-points (e.g., 3.5).

How proficient are you in **writing** English?

Very few words Native proficiency

1 2 3 4 5 6 7

How proficient are you in **writing** Mandarin?

1 2 3 4 5 6 7

How proficient are you in **writing** other languages (specify ________)?

1 2 3 4 5 6 7

How proficient are you in **writing** other languages (specify ________)?

1 2 3 4 5 6 7

E. Language usage

Please write down a number to show which languages you **USE MOST** at home, work and socially. For example, if you use English most at home, put the number “1” next to the word “English.” If you use Mandarin at home but to a lesser extent, put a number “2” next to the word “Mandarin.” If you do not use any of the languages at home, put a “0” next to that language. Do the same for the languages you use most at work and socially.

Language	Use Most At Home	Use most At Work	Use Most Socially
English			
Mandarin			
Others: (specify)			
Others: (specify)			

Please indicate (+) how **OFTEN** you would speak, hear, read, and languages in your daily life.

Speaking	Every Day	Every Week	Every Month	Every Year	Less than Once/year
English					
Mandarin					
Others: (specify)					
Others: (specify)					

Hearing	Every Day	Every Week	Every Month	Every Year	Less than Once/year
English					
Mandarin					
Others: (specify)					
Others: (specify)					

Reading	Every Day	Every Week	Every Month	Every Year	Less than Once/year
English					
Mandarin					
Others: (specify)					
Others: (specify)					

Writing	Every Day	Every Week	Every Month	Every Year	Less than Once/year
English					
Mandarin					
Others: (specify)					
Others: (specify)					

Adapted from Lim, Liow, Lincoln, Chan and Onslow (2008)

Appendix 2

Human Ethics Committee Approval Letter, Information sheet for control participants, Information for participants who stutter, Child assent form, Consent form for adults, Consent form for parents.

Ref: HEC 2012/41

4 May 2012

Ruth Chiam

Department of Communication Disorders UNIVERSITY OF CANTERBURY

Dear Ruth

The Human Ethics Committee advises that your research proposal "Speech motor control in English-Mandarin bilinguals who stutter" has been considered and approved.

Please note that this approval is subject to the incorporation of the amendments you have provided in your email of 2 May 2012.

Best wishes for your project.

Yours sincerely

Michael Grimshaw

Chair , University of Canterbury Human Ethics Committee

Department of Communication Disorders

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Ruth Chiam (Masters of Speech and Language Sciences Student)
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Professor Michael Robb (Supervisor)
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Speech Motor Control in English-Mandarin Bilinguals who Stutter
Information Sheet for Control Participants

I am a Masters student at the Department of Communication Disorders, University of Canterbury. I am interested in the speech motor control of children and adults who stutter and how these compare to the speech motor control of children and adults who do not stutter.

I would like to invite you to participate in my present study. If you agree to take part, you will be involved in a data collection session that will be conducted face-to-face at the University speech and hearing clinic or via Skype if you are unable to be present at site. During the session, you will be asked to:

- Complete a questionnaire about your general use of language. This will take 10-15 minutes.
- Take part in two speaking tasks: 1) a verbal description about a pictures in English and another in Mandarin and 2) a computer-based word-naming task. These procedures will be video-recorded, and will take approximately 40 minutes.

Please note that participation in this study is voluntary. If you do participate, you have the right to withdraw from the study at any time without penalty. If you withdraw, I will destroy any collected information relating to you.

I will take particular care to ensure the confidentiality of all data gathered for this study. The data will only be accessible to Prof. Michael Robb, Dr Emily Lin, Ms Amanda Lee (Doctorate student) and myself. All the data will be securely stored in password protected facilities and locked storage at the University of Canterbury. The data will be destroyed within five years of study completion. The results of this research may be reported internationally, at conferences and in communication disorders journals. I will take care to ensure your anonymity in publications of the findings.

If you have any questions about the study, please contact me (details above). If you have a complaint about the study, you may contact the Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in this study, please complete the attached consent form and return it to me in the envelope provided by day/month.

I look forward to working with you and thank you in advance for your contributions.

Ruth Chiam

Department of Communication Disorders

Ruth Chiam (Masters of Speech and Language Sciences Student)
Department of Communication Disorders
Email: smc179@uclive.ac.nz

Professor Michael Robb (Supervisor)
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UNIVERSITY OF CANTERBURY
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Speech Motor Control in English-Mandarin Bilinguals who Stutter
Information Sheet for Participants who Stutter

I am a Masters student at the Department of Communication Disorders, University of Canterbury. I am interested in the speech motor control of children and adults who stutter and how these compare to the speech motor control of children and adults who do not stutter.

I would like to invite you to participate in my present study. If you agree to take part, you will be involved in a data collection session that will be conducted face-to-face at the University speech and hearing clinic or via Skype if you are unable to be present at site. During the session, you will be asked to:

- Complete a questionnaire about your general use of language. This will take 10-15 minutes.
- Take part in three speaking tasks: 1) a verbal description about a pictures in English and another in Mandarin, 2) oral reading of a short passage in English and in Mandarin, and 3) a computer-based word-naming task. These procedures will be video-recorded, and will take approximately 50 minutes.

Please note that participation in this study is voluntary. If you do participate, you have the right to withdraw from the study at any time without penalty. If you withdraw, I will destroy any collected information relating to you.

I will take particular care to ensure the confidentiality of all data gathered for this study. The data will only be accessible to Prof. Michael Robb, Dr Emily Lin, Ms Amanda Lee (Doctorate student) and myself. All the data will be securely stored in password protected facilities and locked storage at the University of Canterbury. The data will be destroyed within five years of study completion. The results of this research may be reported internationally, at conferences and in communication disorders journals. I will take care to ensure your anonymity in publications of the findings.

If you have any questions about the study, please contact me (details above). If you have a complaint about the study, you may contact the Chair, Human Ethics Committee, University of Canterbury, Private Bag 4800, Christchurch (human-ethics@canterbury.ac.nz).

If you agree to participate in this study, please complete the attached consent form and return it to me in an envelope/email.

I look forward to working with you and thank you in advance for your contributions.

Ruth Chiam

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Department of Communication Disorders

Ruth Chiam
Master of Speech and Language Sciences
Department of Communication Disorders
University of Canterbury
Creyke Road
Ilam
11 April 2012

Child Assent Form

"Speech motor control in English-Mandarin bilinguals who stutter"

Why am I here?
We are asking you to take part in a research study because we are trying to learn more about how children stutter.

Why are they doing this study?
For this study we have created some speaking activities and show them to you from a computer. In the activites, you will be asked to say some words in English and Mandarin, describe a picture in English and in Mandarin, and read a passage in English and in Mandarin. We want to see how well children and adults do when they say different words and sentences. Some children and adults who stutter will need some help with speaking smoothly. We hope to someday use this information to help them speak smoothly. For now, we want to first see how children say words and sentences. We will also ask your parent/guardian if you can be in the study.

What will happen to me?
If you decide to take part in this study, you will sign this form after I (Ruth Chiam) answer any questions you may have. Your parent/guardian will sign a different form. I will have you take part in three activities. The first activity will be to describe two pictures, one in english and the other in Mandarin. The second activity will be to read some English and some Mandarin words shown on the computer screen. The third activity will be to read a short English story and a Mandarin story. You will be recorded on a video camera for all activities.

Will the study hurt?
This study will not hurt.

Will the study help me?
This study will not help you directly but we hope that we may learn more about how children and adult stutter.

What if I have any questions?
You can ask any questions you have about the study. If you have a question later that you didn't think of now, you can email me or call me (Ruth Chiam +64211226231, smc179@uclive.ac.nz).

Do my parents know about this?
This study was explained to your parents and they said that you could be in it. You can talk this over with them before you decide.

Do I have to be in the study?
You do not have to be in the study. No one will be upset if you don’t want to do this. If you don’t want to be in this study, you just have to tell them. You can say yes now and change your mind later. It's up to you.

Writing your name on this page means that you agree to be in the study, and know what will happen to you. If you decide to quit the study all you have to do is tell Ruth or your parents.

____________________________________ __________________
Print Name of Child Date

____________________________________ __________________
Signature of Child Date

____________________________________ __________________
Signature of Researcher Date

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Ruth Chiam
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11 April 2012

Consent Form for Adults

"Speech Motor Control in English-Mandarin Bilingual Speakers who Stutter"

I have read and understood the description of the above-named project. On this basis, I agree to participate in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved. I also understand that I will be video-recorded as part of the procedures of this project.

I understand that I may withdraw from the project at any time, including withdrawal of any information I have provided.

I note that the project has been reviewed and approved by the University of Canterbury Human Ethics Committee.

NAME (please print): …………………………………………………………………..

Signature:

Date:

Department of Communication Disorders

Ruth Chiam
Department of Communication Disorders
University of Canterbury
Creyke Road
Ilam
11 April 2012

Consent Form for parents

"Speech Motor Control in English-Mandarin Bilingual Speakers who Stutter"

I have read and understood the description of the above-named project. On this basis, I agree to my child's participation in the project, and I consent to publication of the results of the project with the understanding that anonymity will be preserved. I also understand that my child will be video-recorded as part of the procedures of this project.

I understand that my child may at any time withdraw from the project, including withdrawal of any information my child or I have provided.

I note that the project has been reviewed and approved by the University of Canterbury Human Ethics Committee.

NAME (please print): …………………………………………………………………..

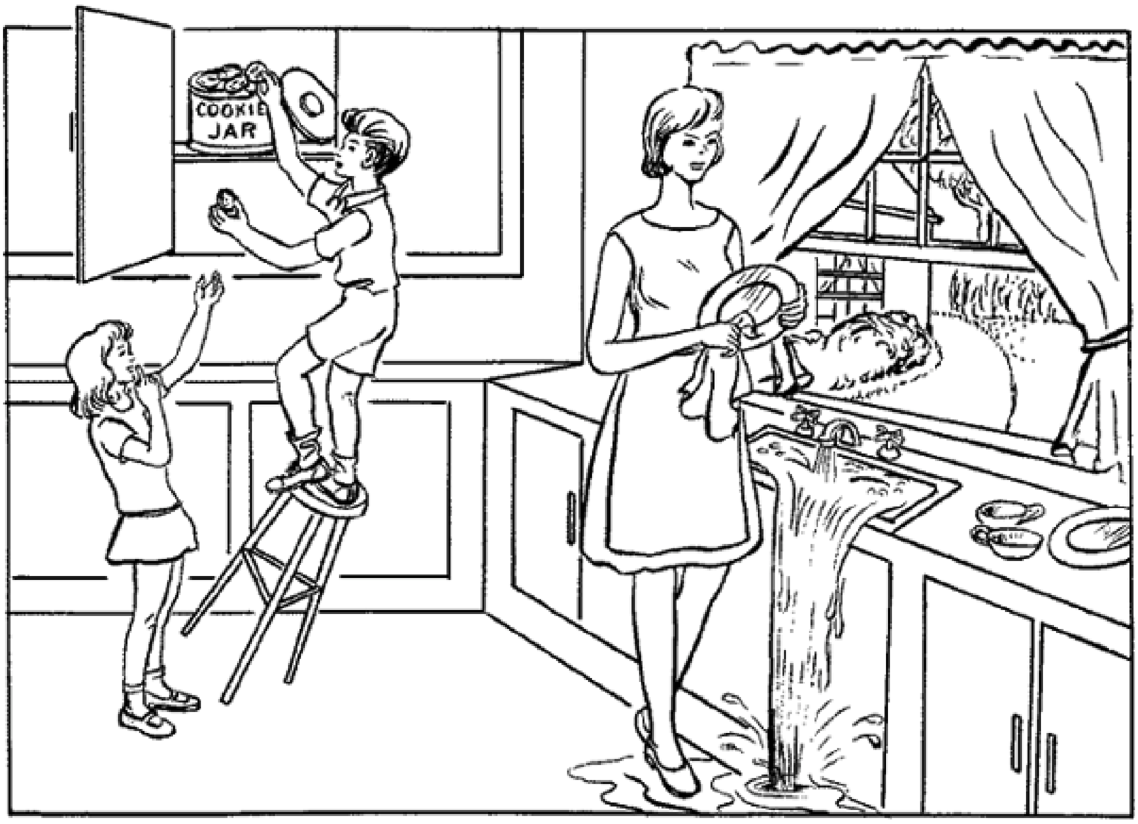
CHILD'S NAME: …………………………………………………………………

Parent's Signature:

Date:

Appendix 3

Picture stimuli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Appendix 4

English and Mandarin word list

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English word list:	Mandarin word list:
/b/	/b/
bee	鼻
bed	北
box	八
ball	博
boot	布
/p/	/p/
pea	皮
pen	賠
park	趴
paw	剖
pooh	瀑
/t/	/t/
tea	提
ten	他
ta	塔
tall	偷
two	兔
/d/	/d/
deep	大
den	笛
dot	搭
dog	躲
do	肚
/k/	
key	褲
Ken	哭
Car	卡
Cough	口
Coo	庫
/g/	/g/
geese	夠
guest	給
god	尬
gauze	狗
goose	固

Appendix 5

English and Mandarin rainbow passage

English Rainbow Passage

When the sunlight strikes raindrops in the air,
they act as a prism and form a rainbow.
The rainbow is a division of white light into many
beautiful colors. These take the shape of a long round
arch, with its path high above, and its two ends
apparently beyond the horizon.

Adapted from Fairbanks, G. (1960). Voice and articulation drillbook, 2nd edn. New York: Harper & Row. pp124-139.

Traditional Mandarin Rainbow Passage

當 陽 光 照 在 空 中 的 雨 滴，
dāng yáng guāng zhào zài kōng zhōng dè yǔ dī,
它 們 就 變 成 一 面 稜 鏡，反 射 出 一 道 彩 虹。
tā mén jìu biàn chéng yí miàn líng jìng, fān sè chū yí dào cǎi hóng.
彩 虹 是 白 色 的 光,分 裂 成 許 多 美 麗 的 色 彩
Cǎi hóng shì bái sè dè guāng, fēn liè chéng xǔ duō měi lì dè sè cǎi
這 些 顏 色 形 成 長 長 的 拱 橋，高 高 在 上。
zhè xiē yán sè xíng chéng cháng cháng dè gǒng qiáo, gāo gāo zài shàng.
它 的 兩 端 顯 然 超 越 地 平 線。
tā dè liăng duān xiăn rán chāo yuè dì píng xiàn.

Adapted from Fairbanks, G. (1960). Voice and articulation drillbook, 2nd edn. New York: Harper & Row. pp124-139.

Simplified Mandarin Rainbow Passage

当 阳 光 照 在 空 中 的 雨 滴，
dāng yáng guāng zhào zài kōng zhōng dè yǔ dī,
他 们 就 变 成 一 面 稜 镜，反 射 出 一 道 彩虹。
tā mén jìu biàn chéng yí miàn líng jìng, fān sè chū yí dào cǎi hóng.
彩 虹 是 白 色 的 光，分 裂 成 许 多 美 丽 的 色彩。
Cǎi hóng shì bái sè dè guāng, fēn liè chéng xǔ duō měi lì dè sè cǎi
这 些 颜 色 形 成 长 长 的 拱 桥，高 高 在 上。
zhè xiē yán sè xíng chéng cháng cháng dè gǒng qiáo, gāo gāo zài shàng.
他 的 两 端 显 然 超 越 地 平 线。
tā dè liǎng duān xiān rán chāo yuè dì píng xiàn.

Adapted from Fairbanks, G. (1960). Voice and articulation drillbook, 2nd edn. New York: Harper & Row. pp124-139.